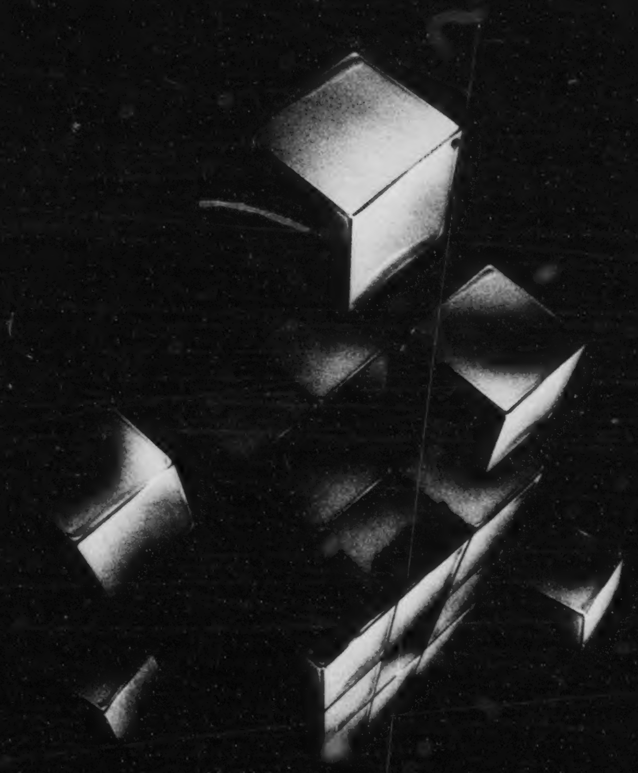

Competing in the New Global Economy

Report of the Premier's Council
Industry Studies
Volume II

Industry Studies
Volume II

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PREFACE

During its early meetings, the Premier's Council was challenged by Premier David Peterson to examine the economy of Ontario objectively, determine how to enhance its strengths while addressing its weaknesses, and develop policies for its future. The services of outside consultants were retained and a special secretariat was established to assist the Council in its in-depth study of Ontario's competitiveness.

Volume II is the first of two background reports summarizing the research that the study team presented to the Council. It provides a detailed discussion of the competitiveness of twelve of the key industry sectors which were analyzed. Also presented are the results of a specially commissioned survey of Ontario start-up companies, which identifies factors constraining their development and examines the role of venture capitalists in creating and financing new businesses. The role and further potential of Ontario Hydro to stimulate provincial development is also examined.

This volume provides more detailed insights into the competitive position of Ontario industry and should be read as a companion piece to Volume I, the report of the Council. The material in Volume II is intended to facilitate the discussion of Ontario's competitive future and assist in setting the economic agenda for the next decade. Volume III summarizes the research done for the Council on economic development policies in various jurisdictions around the world.

The preparation of Volume II was a complex undertaking and involved the participation of many individuals, including the Canada Consulting Group, Telesis, their associates, and the staff of the Premier's Council Secretariat, all of whom are acknowledged in Appendix A. Altogether, over one thousand industry, academic, labour, and government officials in Ontario were interviewed during the research effort. Hundreds more were interviewed in other provinces and abroad.

Special thanks are due to the many members of the Ministry of Industry, Trade and Technology who graciously shared their insights and information with members of the study team. Special mention must also be made of the work of Kathryn Randle in preparing the reports for publication and of Woodbridge, Reed and Associates, whose study of the forest products industry provided the basis of the analysis and conclusions in Chapter II.

CHAPTER I
INTRODUCTION

The first volume of the Premier's Council Report summarized all of the research done for the Council, as well as the Council's proposed strategy and recommendations to the government. The descriptions of individual industries in Volume I were, of necessity, very brief. In this volume, twelve of the key sectors studied are described at much greater length and the competitive issues facing each sector are analyzed in more depth.

APPROACH TO INDUSTRY ANALYSIS

The Council's approach to industry analysis, described at length in Chapter 1 of Volume I, has been based on several fundamental principles. First among these is that traded businesses—those whose output can cross borders (like autos and software)—are fundamental to wealth creation in the province. Accordingly, the sectors the Council selected for study in depth were all in traded businesses. All of the sectors in this volume are in manufacturing except for one—software. The research team also did case studies in traded service businesses in other sectors, including banking, life insurance, property and casualty insurance, stock brokerage, and consulting engineering. The results of these case studies contributed to the policy development process, just as the twelve sector studies did. Some of the insights from the case studies were described in Volume I.

A second fundamental concept underlying the Council's approach to industry analysis is that value-added per employee is a handy and useful measure of the wealth creation capacity of traded businesses. Greater value-added per employee in an economy can come from:

- Producing goods and services more efficiently than others who make similar goods and services, or
- Making unique products for which customers will pay a price premium.

Greater value-added per employee may result from improved manufacturing processes, but it can also come from establishment of a brand name or better customer service.

A third fundamental element in the Council's approach to competitive analysis was the recognition that as less developed countries industrialize, they tend to erode the more developed countries' international market share of labour intensive products. This process is often called industrial restructuring. Countries begin by exploiting their natural resources and then move to making products which can be manufactured anywhere and do not require a high level of skill or organizational complexity. Over time, successful economies steadily climb up the ladder of industrial complexity, making ever-higher value-added per employee products.

This industrial restructuring process is ongoing, and no country can afford to stand still by making tomorrow what it makes today. Japan began its postwar development in clothing, ceramics, toys, and similar products. From there it quickly began to build in the late 1950s and 1960s major core industries of higher complexity, such as steel, basic chemicals, and autos. By the 1970s, Japan's industrial structure was starting to shift to higher value-added per employee businesses in computers, machine tools, and advanced electronics. Japan is now firmly among the ranks of leading developed economies and can invest confidently in the most advanced and sophisticated businesses in the world. Korea is now following Japan up this ladder. Many observers have been surprised at the speed with which Korea has moved from lower value-added per employee businesses like shipbuilding to strong competitive positions in autos and colour televisions. And still other countries like Thailand are now following Korea.

A final observation which is fundamental to the Council's work is that competitive analysis must be carried out at the level of individual business segments. The Ontario economy is often spoken of as a single entity or a collection of broad industry entities, such as the automotive, steel, or life insurance sectors. In reality, the Ontario economy is made up of tens of thousands of individual companies competing in tens of thousands of domestic and international markets. The competitive dynamics of each of these markets and the corresponding challenges facing each of these companies are different.

For example, a company manufacturing and selling injection molded automotive trim parts to the original equipment automotive market (e.g., GM, Ford, Chrysler) may appear to be in the same business as a plastic fabricator selling automotive replacement parts to the aftermarket, but in reality each company may be competing on an entirely different basis. The original equipment supplier selling to only a few customers has to meet rigorous quality standards and must bid on an annual or bi-annual basis for major new contracts. The aftermarket supplier, on the other hand, who has to service hundreds of customers or rely on secondary distributors, may be able to get by with lower quality products, and must bid on a continuing basis for accounts. The manufacturing technology in each business may be similar, but the competitive drivers can be quite different.

The unique competitive situation of each of the many thousand businesses making up the Ontario economy is the single greatest problem in developing an effective analysis of the competitive position and prospects of the province. Industry statistics which are gathered according to traditional SIC code definitions may give a misleading picture of how or even what businesses operate in the province. For example, discussions of competitiveness in the consumer electronics business are often not that useful; discussions of competitiveness at the level of the colour television business are better. And depending on the actual dynamics of competition, the most useful level of discussion may be the business segment of large screen colour televisions, which have a different competitive dynamic than small screen colour televisions. While Ontario may be able to be a competitive location for large screen colour television production, it certainly is not a competitive location for small screen colour TVs.

THE RESEARCH PROGRAM

Naturally, it is not possible to analyze the thousands of individual traded businesses in the province according to their unique competitive drivers. Instead, the research team identified leading firms within each industry sector and analyzed a range of individual business segments in which each firm participated. Typically, all of the large firms and a sampling of middle and small businesses in each sector were interviewed in the course of the research. Often, repeat visits were made to each company to obtain follow-up data and analytical assistance. Most of the top 50 exporters in the province and the top 25 threshold firms were also interviewed in a similar fashion, regardless of the industry they were in.

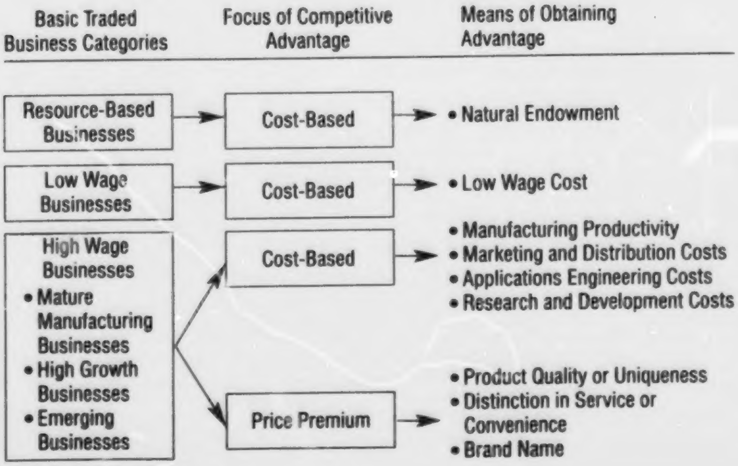
After the initial competitive analyses were completed, the research task was to use the insights gleaned from the business segment level analyses to develop more general competitive categorizations of the business segments according to the competitive similarities identified. For example, many of the specialty chemical businesses in Ontario were found to have similar competitive problems and could be usefully thought of as a business group relative to commodity chemical businesses in the province, which generally had a different competitive profile. Always the driving principle behind any categorization of business within industry sectors was the competitive similarities or differences facing the various business segments and the concommitant usefulness of any segment grouping from a public policy point of view.

Ultimately, the analyses of individual segments and sectors allowed the creation of an overall framework for viewing the province's competitive position simply and clearly. In the first volume of the Premier's Council report, the competitive position of Ontario's industries was summarized using a framework that grouped all traded business segments in the province into one of five categories according to competitive similarities, and in some cases their growth prospects.

In this volume, we will sometimes describe various sectors as each falling wholly within one of these categories. For example, food processing is discussed as a resource-based industry, though that is only the predominant type of business in the food processing sector. Some food processing businesses, like bacon and whiskey, compete on a superior quality and brand image basis, and raw materials are not such a critical competitive factor. Similarly, steel is described as a mature manufacturing industry, but some segments of the steel industry behave more like low wage

EXHIBIT 1.1

A FRAMEWORK FOR ANALYSING
COMPETITIVE ADVANTAGE IN TRADED BUSINESSES


Basic Traded Business Categories
Focus of Competitive Advantage
Means of Obtaining Advantage
Resource-Based Businesses
Cost-Based
• Natural Endowment
Low Wage Businesses
Cost-Based
• Low Wage Cost
High Wage Businesses
• Mature Manufacturing Businesses
• High Growth Businesses
• Emerging Businesses
Cost-Based
• Manufacturing Productivity
• Marketing and Distribution Costs
• Applications Engineering Costs
• Research and Development Costs
Price Premium
• Product Quality or Uniqueness
• Distinction in Service or Convenience
• Brand Name

Source: Developed by Telesis

businesses and others in certain specialty areas are really high growth business having more in common with aerospace and computers than with steel. One must keep these caveats in mind when reading Volume II.

The Special Studies

This volume also contains the results of two other special industry studies undertaken for the Council. Analysis of a survey of 71 Ontario start-up companies (less than seven years old) in traded businesses shed a great deal of light on the origins, prospects, and impediments to success facing such companies. The survey was carried out in face-to-face interviews which also explored the competitive position of each start-up and the usefulness and relevance of government assistance programs. One of the most dramatic findings was that entrepreneurs come overwhelmingly from large indigenous companies in Ontario. Such indigenous firms are critical to the new business formation process because they are where managers are most likely to develop a full set of business skills, including marketing, product development, and production.

A smaller follow-up start-up study of the origins and development of spin-off companies from Bell Northern Research and Northern Telecom was also undertaken. Fourteen such companies were chosen for study among the more than 50 firms that have been created by people leaving those two organizations or their offspring.

To deepen the Council's understanding of the role and adequacy of new business financing in Ontario, a review of the venture capital industry, including comparisons with other jurisdictions, was conducted. This analysis revealed an important dearth of early stage, participative venture capital investors in Canada. Such investors have been a critical ingredient in the development of high technology industries in California, Massachusetts and other jurisdictions. This and other insights became the foundation of the Council's policy initiatives relative to enhancing the formation and success rates of new traded businesses in the province (See Chapter VII of Volume I).

The second major area of special study included in this volume is a review of the role of Ontario Hydro in provincial economic development beyond its central mandate to provide low cost, reliable electric power. This analysis focussed on Hydro's activities in research and development, procurement, and the creation of new business spin-offs from its core activities. Comparisons with Hydro Quebec as an instrument of economic development in Quebec were also made. Ontario Hydro has made great strides in expanding its economic development role, but much more remains to be done, as the directions for future policy in this chapter indicate.

These industry sector studies and related analyses supported the Council in developing its policy agenda. They do not, however, constitute all the industrial input which assisted in the formulation of the Council strategy and recommendations. In addition to the work presented here, international statistical comparisons of all manufacturing industries were compiled for Ontario and nine countries. Structural and ownership comparisons were also made for the leading exporters in all those jurisdictions. A statistical database was constructed of all Ontario firms with over $10 million in export sales. This and other sources were the basis for a special study of the needs and prospects of Ontario threshold companies. The most important results of each of these analyses were summarized in Volume I. The Council research effort also included a number of case studies which will not be published as such, but have been incorporated into the sector pieces in this volume or in the summary material presented in Volume I.

THE COMPETITIVE CHALLENGES OF CORE INDUSTRIES

CHAPTER II

THE FOREST PRODUCTS INDUSTRY

Ontario's forest industry developed initially along the Great Lakes during the 1800s, but moved steadily northward as the pine forests of the south became depleted. By the early 1900s, newsprint mills had become established, with production based primarily on spruce. In the 1950s, the kraft pulp segment of the industry developed using spruce and pine, which are widely regarded as producing premium pulp because of their slow-growing, long-fibre characteristics.

Today, the forest products industry in Ontario accounts for 2.2 percent of the province's gross domestic product and employs approximately 75,000 people, or 1.8 percent of the workforce. Comparative figures for other provinces and Canada as a whole are provided in Exhibit II.1.

However, the comparatively low figure for total employment conceals the industry's significance to the economy of northern Ontario, where many communities depend on forest products for their livelihood. The industry is responsible for 80 percent of manufacturing jobs in the northwestern region of the province and 35 percent in the northeast.

Ontario accounts for almost one-quarter of total Canadian forest product shipments. Paper and allied goods form the largest component, making up some 75 percent of the province's production.

Ontario's exports of forest products are substantial, amounting to $3.3 billion in 1985. The manufacturing sector of the industry ranks sixth in Ontario in terms of value of shipments.

CURRENT POSITION

The industry has returned to healthy profitability after a number of very difficult years in the early 1980s when recession, combined with unfavourable exchange rates, (that is, a strong Canadian dollar) caused substantial losses. At that time, the strong U.S. dollar allowed European competitors to grab a growing share of the American market for forest products.[1]

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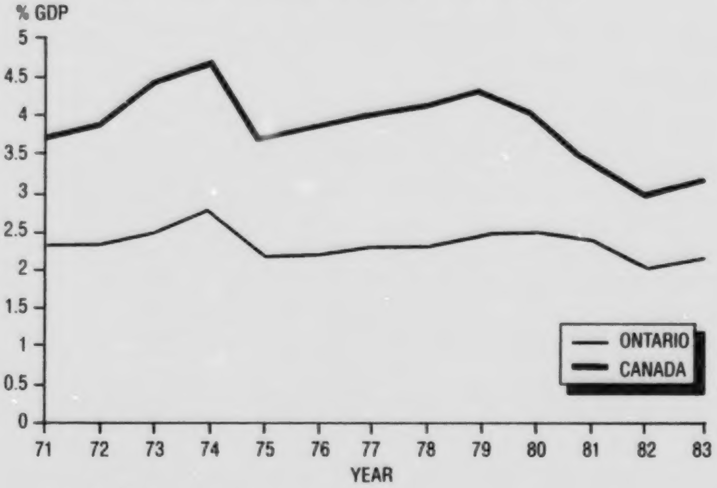
[1] This chapter is heavily based on a 1987 study of the Ontario Forest Products Industries done by Woodbridge, Reed and Associates for the Ontario Ministry of Natural Resources.

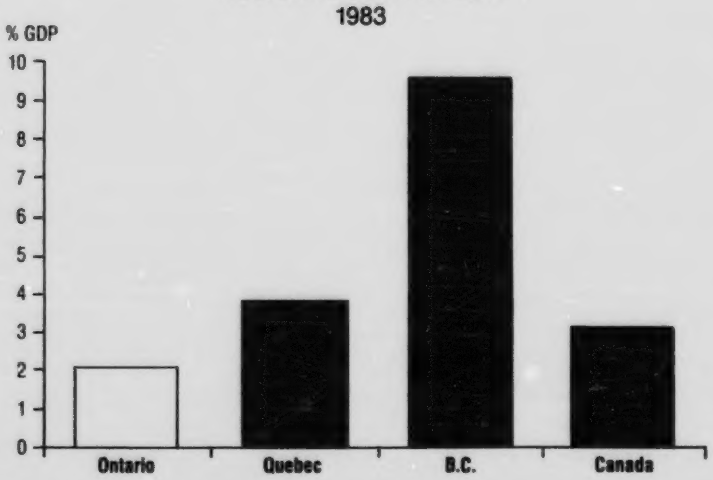
EXHIBIT II.1

FOREST INDUSTRIES' CONTRIBUTION TO GDP



Source: Statistics Canada.

FOREST INDUSTRIES' CONTRIBUTION TO GDP
REGIONAL COMPARISON
1983



Source: Statistics Canada.

This difficult period led to a perception that the forest products business was a sunset industry facing inevitable decline. However, the rise of the U.S. and Canadian currencies was abruptly halted in 1985, and their subsequent decline relative to the currencies of Canada's competitors has been a key factor in helping the industry regain its cost competitiveness. Forestry companies have also undertaken a substantial and costly upgrading process, and will have spent an estimated $1.8 billion between 1980 and 1989 to modernize facilities.

Currently, the pulp and paper industry has a positive trade balance, and much of the Ontario forest products industry is operating at or near full capacity in response to robust North American demand for its products. The apparent health and current profitability of the industry do, however, conceal some fundamental problems that could prevent it from taking full advantage of future market opportunities.

CHALLENGES FACING THE INDUSTRY

The Ontario forest products industry faces growing threats from several sources:

- There is increasing competition in pulp and paper markets from new, technologically sophisticated facilities in the United States, Europe, and elsewhere in Canada. These facilities give producers competitive advantages in product cost and quality
- Countries such as Brazil, where wood resources are abundant and costs are low, are developing their own pulp and paper businesses. These countries represent threats to Ontario's traditional strength in supplying competitively priced commodity products
- Substitute materials, including aluminum, concrete, plastic, and steel, are now competing with wood and other forest products as building and packaging materials. This means that market demand for some forest products is growing more slowly, while the demand for others is rising, requiring producers to shift their product mixes.

Concerns about the future of Ontario's forest products industry stem from the fact that it has not kept pace with these fundamental shifts in the nature of competition in the international marketplace. Two changes in particular—technological advances and altered product mixes—will affect the industry's competitive prospects.

Advances in pulp and paper technology include changes in the size and scale of plant and equipment, as well as new processes that improve cost-effectiveness and the quality of the product. Altering product mix involves shifting production from commodities like newsprint and lumber studs to goods with higher value-added, such as specialty papers and customized wood products.

Ontario plants have not generally adopted these technological improvements or responded to changes in the pulp and paper market by shifting their product mix at the same pace as their competitors have. This leaves them vulnerable on several fronts. First, despite new and increased demand for higher-quality and specialty papers, Ontario producers have continued to rely mainly on lower-value bulk commodities, such as newsprint, pulp, and basic grades of lumber. The industry has usually been very successful in exploiting markets for these products, but changes in market demand mean these sectors are likely to grow more slowly in the future. Moreover, new competition from low-cost countries will capture growing shares of the market for commodities, particularly if exchange rate fluctuations wipe out one of the major advantages the Ontario industry has had until now.

Second, with smaller-scale machines, older plants, and outdated processes, Ontario producers find their manufacturing productivity lagging behind that of their competitors, even for the bulk commodities that make up most of their production. This fact has been masked to some extent by the favourable exchange rate for the Canadian dollar. But should that rate change, lagging productivity would have immediate effects on the industry's ability to compete internationally.

Meanwhile, Ontario's competitors in the United States, Europe, and other parts of Canada have responded to market demand, diversifying into manufacturing higher-value, more specialized products, such as super calendered and lightweight coated papers. (These papers are used for newspaper advertising inserts, magazines, catalogues, and so on.) By shifting to products with higher value-added, Ontario's competitors will not be as vulnerable to shifts in exchange rates because the basis for competition in those sectors is not price—as it is for commodities—but product quality, manufacturing productivity, or other factors.

In short, the strengths that have contributed to growth, profitability, and employment in Ontario's forest products sector in the past are no longer all that is needed to compete in international markets. The demand for commodities, where the Ontario industry is a strong competitor, is not rising as quickly as the demand for specialty and high value-added products, market segments in which Ontario is much less competitive. Moreover, Ontario is vulnerable to exchange rate fluctuations and to new competitors in the segments where it is traditionally strong.

Producers elsewhere in Canada and in other parts of the world have recognized and responded to these changes in the marketplace and in the determinants of international success. The Ontario industry must do the same if it is to survive these challenges and compete successfully in the international marketplace. These challenges are examined further in the next section.

INDUSTRY COMPETITIVENESS

Pulp and Paper

Ontario pulp and paper manufacturing suffers from three weaknesses that hinder its international competitiveness: outdated and small-scale plants and equipment; insufficient response to the changing demands of the marketplace; and inadequate attention to technological changes that could improve its competitive position.

Ontario's forest companies have invested considerable sums of money in the last decade to upgrade aging facilities. But these funds have usually been devoted to making the same products a little more efficiently. There have been no greenfield mills built and virtually no major investments in new paper machines and new products. As a result, Ontario producers continue to operate with older equipment that is below world economies of scale.

Sixty percent of newsprint machines currently operating in Ontario were installed before 1930; another four were built between 1930 and 1960; one was installed between 1960 and 1980; and three more have been built since 1980. However, none of the three newest machines produces the improved newsprint that is the most attractive segment of that market. Mills producing printing and writing paper are also generally old and offer little by way of economies of scale. One exception is St. Marys Paper in Sault Ste. Marie, which is installing a new paper machine to manufacture high quality super calendered printing paper. By contrast, Ontario's competitors have been establishing modern, highly economic facilities. In Wisconsin, Michigan, and Minnesota, for example, a major greenfield paper mill and five new lightweight coated paper machines have been installed since 1975.

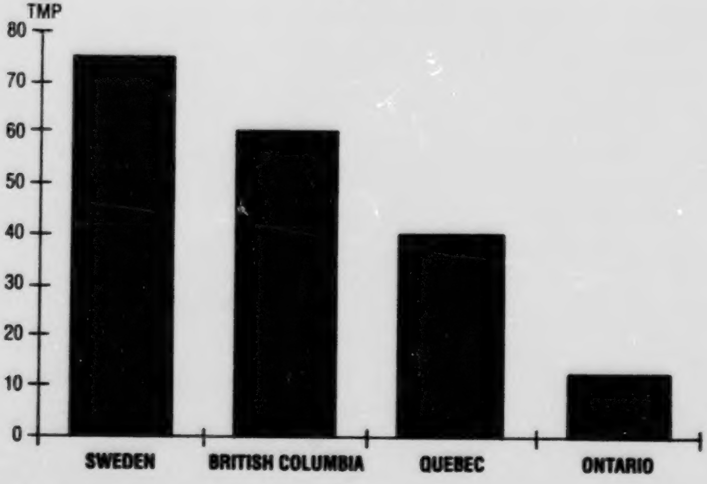
A second factor impeding Ontario's ability to compete internationally is the fact that the industry has not responded quickly enough to shifts in the composition of the market for pulp and paper products. Although the demand for bleached kraft pulp and newsprint (the commodities where Ontario is strong) continues to grow in absolute terms, it is falling relative to the demand for specialty products. In turn, the demand for specialty products is rising both absolutely and in relative terms. In the marketplace, this means greater fragmentation and a recognition by competitive producers that they have to devote more attention to tailoring their products to the needs of the end user.

U.S. demand for lightweight coated paper, for example, increased from 1.8 million tonnes in 1976 to 3.4 million tonnes in 1986—equivalent to the production capacity of eight economy of scale paper machines. Ontario has produced virtually none of this type of paper over the same period. U.S. demand for the highest quality super calendered groundwood paper has also expanded rapidly—from nothing in 1980 to more than 500,000 tonnes in 1986. Yet Ontario will not be able to supply this market until late 1988, when St. Marys Paper will start production using a new paper machine.

Finally, the Ontario industry has also been slow to take advantage of new pulping technologies, such as thermomechanical pulping, which produces low-cost, high-quality newsprint (See Exhibit II.2). Other new pulping technologies, such as bleached chemi-thermomechanical pulp, are not employed at all, even

EXHIBIT II.2

USE OF THERMOMECHANICAL PULPING IN NEWSPRINT PRODUCTION



Source: Woodbridge, Reed and Associates, *A Study of the Ontario Forest Products Industry*, 1987.

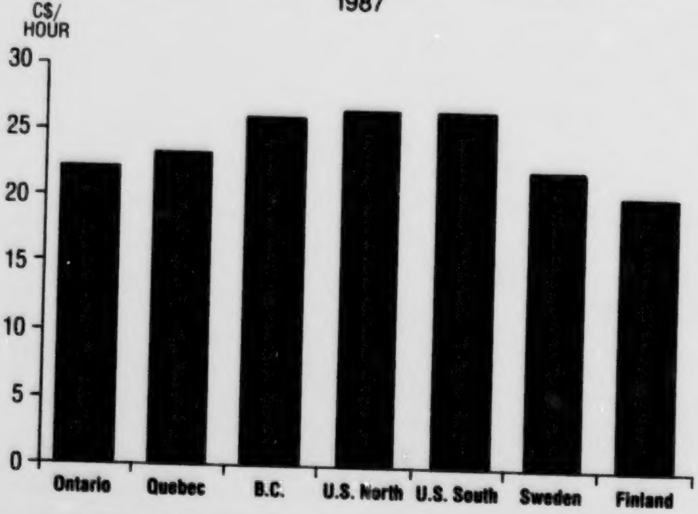
though these processes can make use of a broader range of trees, such as hardwoods, of which Ontario has considerable reserves. Demand for pulp produced by these new methods is expected to increase at a much higher rate than in the past decade.

Despite these negative factors, Ontario's pulp and paper industry is still reasonably cost competitive in several market segments (See Exhibits II.3, II.4 and II.5):

- Labour costs are comparable to those of Ontario's major European competitors and below those in the United States. But Ontario lags behind its competitors in productivity, as measured by the number of man-hours necessary to produce a tonne of newsprint—a reflection of the industry's dated and small-scale equipment
- Ontario's wood costs (the most important component of total product cost) are competitive with Quebec's, but much lower than costs in Europe. However, mills in B.C. and the southern United States can purchase trees more cheaply. The disadvantage relative to B.C. is partly offset by Ontario's proximity to markets

EXHIBIT II.3

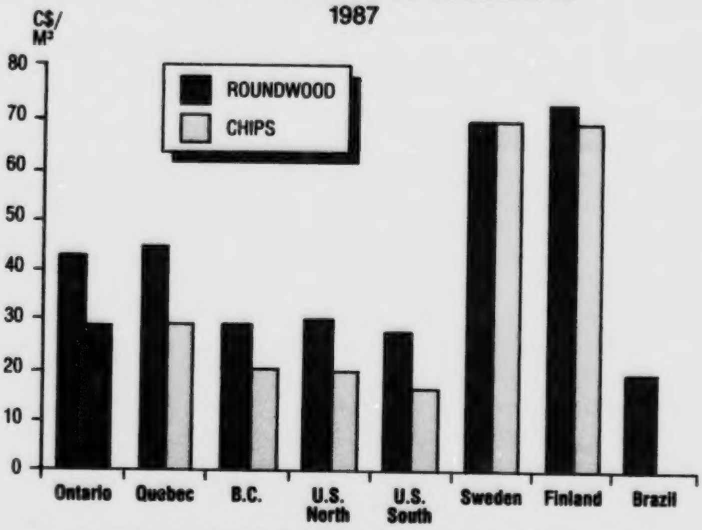
PULP AND PAPER INDUSTRY
COMPARISON OF TOTAL HOURLY COMPENSATION
1987



Source: Price Waterhouse, *Forest Sector Advisory Council Study*; Woodbridge, Reed and Associates.

EXHIBIT II.4

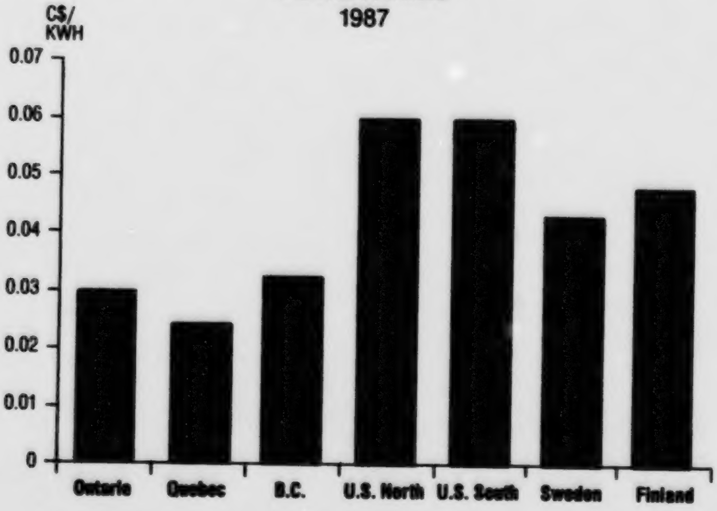
WOOD COSTS
SOFTWOOD - DELIVERED TO MILL SITE
1987



Source: Price Waterhouse, *Forest Sector Advisory Council Study*; Woodbridge, Reed and Associates.

EXHIBIT II.5

POWER RATES
1987



Source: Price Waterhouse, *Forest Sector Advisory Council Study*; Woodbridge, Reed and Associates.

in the United States and Europe, while lower Ontario energy costs reduce a portion of its U.S. advantage

- Power rates in Ontario are below those of all major competitors except Quebec.

Despite its aged facilities Ontario is cost competitive in some products, particularly those that are energy-intensive (such as mechanical fibre-based printing papers), but is at a competitive disadvantage in products that are wood-intensive (those involving chemical pulping processes).

However, Ontario's competitive cost position is unstable and vulnerable—unstable because exchange rate fluctuations could alter the situation very rapidly, and vulnerable because of the age and scale of the industry's assets. The key factor underlying the pulp and paper industry's favourable competitive position has been the weak Canadian and U.S. dollars. The decline of these currencies has reduced the effectiveness of European competitors in the American market, leaving the way open for Canadian producers to fill the gap. Any reversal of this trend would leave the Ontario industry vulnerable. Even without such a reversal the industry still faces competitive threats from low-cost producers and from producers that have already changed their product mix to meet market demand. Quebec and the southern United States are already lower-cost producers; emerging producer countries could pose more significant threats in the future, squeezing profit margins for Ontario pulp and paper companies. The European producers have already acted to escape an uncompetitive cost position by changing their product mix and vertically integrating their chemical pulping operations.

Lumber Industry

Ontario's sawmills benefit from being nearer major markets than competitors in western Canada, but this is offset by the higher cost and lower quality of Ontario logs and the smaller capacity of the province's mills. Ontario's three largest sawmills have a capacity of about 250,000 to 300,000 board feet per shift. In British Columbia, there are mills with a capacity of up to 500,000 board feet per shift.

In addition, many Ontario mills have a low level of automation and processing technology and, consequently, higher labour costs. The fact is that most Ontario mills are too small in scale to consider technology-related capital investment. A 1985 report on automation by H.A. Simons Ltd. identified the process control systems at 24 selected installations as obsolete. Ontario mills have simply not adopted the optical scanning and other techniques that can streamline production and optimize the use of the wood resource. As a result, unit costs are high and the yield of lumber from the logs is low.

There is also an emphasis by the Ontario industry on manufacturing basic, low value-added products such as lumber studs. These products face strong competition from similar commodity lumber made more cost effectively in modern mills in the southern and western United States, B.C., Alberta, and Quebec. Opportunities to diversify into higher value-added products, such as mechanical stress-rated lumber have not been pursued, even though the technology was readily available.

The difficulties facing the sawmills have been compounded by the 15 percent export tax on softwood lumber, which gives U.S. mills a considerable advantage and makes many Ontario mills only marginally profitable at best. It was the high productivity of mills in British Columbia, not Ontario, that helped Canada capture some 30 percent of the U.S. market, prompting protectionist action by the United States.

Panelboard Industry

The product group of greatest interest in Ontario's panelboard sector is waferboard. Ontario underwent a significant expansion of waferboard capacity in the 1970s and developed a strong competitive position, becoming the dominant waferboard supplier at that time. By the early 1980's, Ontario waferboard production represented more than 50 percent of Canadian waferboard output, but this has since dropped back to 40 percent, largely because of failure to modernize plants to achieve competitive scale. However, companies could not justify such expenditures when competitive pressures had acted to reduce returns and rates of capacity utilization.

Today, Ontario's facilities are generally smaller and older than those in competing jurisdictions, particularly given the number of new plants planned or starting up in B.C., Alberta, and Quebec. The Ontario mills therefore tend to be limited to competing in the market for low-value sheathing, another commodity product. Yet many of the mills are not at the current economy of scale. The production of Ontario mills reflects this, with annual capacities in the range of 100 to 150 million square feet. Modern plants in western Canada can manufacture about 250 million square feet annually. As a result, the future of this part of Ontario's forest products industry is in jeopardy.

THE INDUSTRY'S MARKETS

Paper Products

The demand for forest products shows consistent growth over the years, and the Canadian Pulp and Paper Association predicts that world demand for paper and paperboard will continue to expand by 2.5 percent annually. Shipments of pulp and paper from Canadian companies are expected to rise from 20.8 million tonnes in 1980 to 30 million tonnes by 1995.

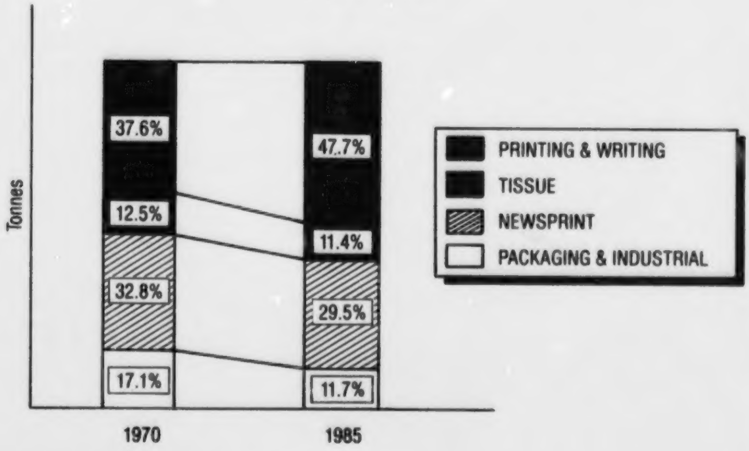
Demand for the bulk commodities that make up most of Ontario's pulp and paper production has been growing steadily at between one and two percent annually. However, orders for higher-priced printing and writing paper, such as super calendered and lightweight coated paper, have been expanding much more rapidly.

This trend is clearly evident in U.S. market trends. U.S. demand for printing and writing paper accounted for 37.6 percent of the U.S. demand for paper products in 1970. By 1985, that figure had grown to 47.7 percent. Newsprint, by contrast, declined from 32.8 percent to 29.5 percent of total demand (See Exhibit II.6).

Despite this shift in demand, Ontario's production of commodities as a percentage of total paper and paperboard production has remained unchanged at 60 percent during the last ten years. Ontario's competitors have not been slow to react. Finland, for example, reduced the ratio from 55 percent to 40 percent in the

EXHIBIT II.6

SHIFT IN DEMAND FOR PAPER—UNITED STATES
1970 - 1985



Source: Communication and Information Services.

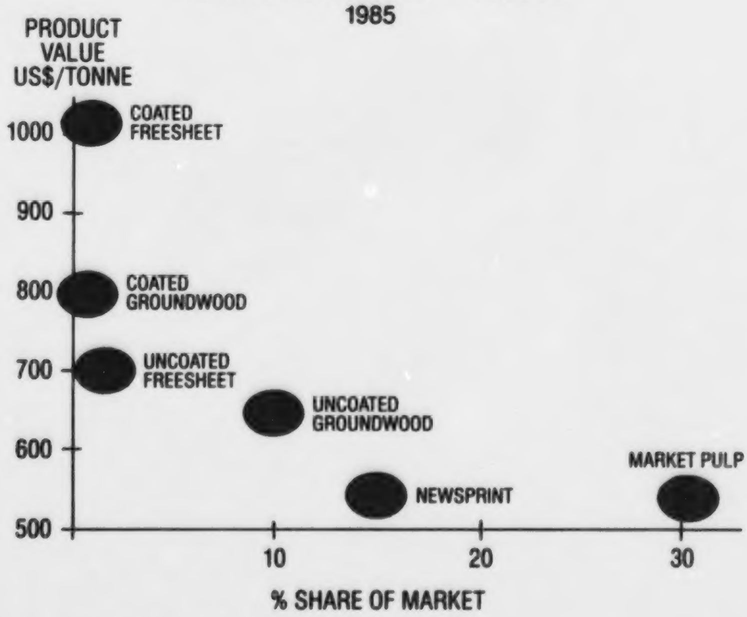
same period, as it sought to maximize the value-added from its relatively costly wood resources by increasing production of higher quality papers and decreasing production of commodity products.

The figures on the Ontario industry's penetration of the U.S. market provide a clear picture of its strong bias towards the low-value-added end of the product spectrum. Ontario companies hold a 30 percent share of the U.S. market for pulp, valued at about $525 U.S. per tonne, compared with one to two percent of the U.S. market for coated freesheet and coated groundwood paper, valued at $1000 per tonne and $800 per tonne respectively (See Exhibit II.7).

Market projections indicate that U.S. demand for many types of high-quality paper will expand at as much as double the rate of newsprint. Woodbridge, Reed and Associates predict that U.S. demand for newsprint will climb by 3.3 million tonnes between 1985 and 2000. Printing and writing paper demand is forecast to

EXHIBIT II.7

ONTARIO SHARE OF U.S. MARKET
RELATIVE TO VALUE OF PRODUCT
1985



Source: Woodbridge, Reed and Associates estimates.

increase by 9.6 million tonnes in the same period. So far, this increasing U.S. demand for high-quality printing papers has been met primarily by U.S. and Scandinavian producers, who have recognized the shifts in the market, responded with new product mixes, and adopted the technologies necessary to capture a healthy market share.

The market for commodities is not only growing more slowly, it also is becoming more fragmented. Even producers of softwood bleached kraft pulp must now differentiate pulps for specific uses. Similarly, standard newsprint used to serve virtually the entire market for uncoated groundwood printing paper. Today, however, there are several grades, ranging from basic newsprint to improved newsprint to high-quality super calendered papers. A few North American suppliers, along with most of the Swedish industry, are producing this upgraded newsprint. Again, adoption of appropriate technology has enabled producers to respond to a fragmented market by tailoring their products to end uses.

Panelboards and Lumber

The demand for panelboards is expected to increase significantly for reconstituted panels, and less so for plywood. Consumption of reconstituted panels is forecast to climb by as much as 400 percent in northeastern and north-central regions of the United States by the year 2000. However, success for Ontario producers in these markets could be hampered by the current lack of modern mills that can achieve economies of scale.

The market prospects for lumber have been clouded by the imposition of the 15 percent export tax on products destined for the United States. Ontario's share of Canadian softwood lumber production has declined steadily during the last three decades, from 11.1 percent in 1950 to 7.6 percent in 1983, and the industry is not as efficient as B.C.'s softwood lumber producers.

The industry needs new investment to take advantage of market opportunities. But investment can be difficult to justify when profits are low, as they are at present. Ontario mills will be hard-pressed to compete with the big B.C. mills, which are not only more productive but have a superior wood resource. However, there may be an opportunity for the Ontario industry to satisfy consumer demand for flexible wood cuts and specialized needs. There is also growing demand for mechanically stress-rated lumber, a trend that no Ontario mill has yet capitalized on.

INVESTMENT CLIMATE

The Ontario forest products industry has not benefited from the entry of new players, who could have initiated the modernization and new products necessary to take full advantage of changing markets. New entrants have been deterred for several reasons:

- Ontario's forest resources appear to have been committed for use by the existing industry under forest management agreements, yet there is significant underutilization of the wood resources by the industry. For example, large quantities of softwood reserves are not accessible without harvesting a significant amount of hardwood. Yet the Ontario industry has not introduced technologies that would enable it to use that hardwood, so the softwood remains inaccessible
- The industry has not received high priority in the strategic plans of Ontario governments. However, increasing emphasis is now being placed on policies to improve the northern economy
- Ontario Hydro has been less aggressive than Hydro-Quebec in providing low-cost power to the industry. Ontario Hydro has recently announced initiatives to reverse this policy
- The industry itself acknowledges that it is falling behind other parts of Canada in the process of modernization, but it blames government for creating an unfavourable investment climate. The industry cites workers' compensation costs, tougher environmental regulations, and pay equity as examples, saying that Ontario's rules are more stringent and costly to comply with than those in competing jurisdictions.

SUMMARY

The Ontario forest products industry has an excellent opportunity to maintain and improve its contribution to the provincial economy. Demand for wood products is growing steadily, Ontario has a highly regarded wood resource, and the industry is still cost competitive in pulp and paper, despite its outdated technology and assets, smaller scale, and lower productivity.

The improving profits now being experienced by the industry following several lean years, together with the breathing room provided by the relative value of the Canadian dollar, present an ideal opportunity for Ontario's forest products industry to restructure, invest in modern technology, and diversify its product lines, moving into more stable and less vulnerable competitive positions in the higher-value segments of the market.

CHAPTER III
FOOD PROCESSING

Food and beverage processing is an important economic activity in Ontario. Its value-added and employment are significant, ranking second only to transportation equipment. The industry faces many competitive challenges—sub-scale plants, high processing costs, and high raw materials cost. These obstacles to competitiveness are particularly challenging when viewed in the context of a possible free trade regime with the United States, home of the industry's major competitors. Nevertheless, there are some high value-added segments in the industry, and some companies have been able to attract price premiums for their products through effective marketing, superior technology, or better quality. This chapter focusses on the key factors determining the industry's competitive position, some success stories about those higher value-added food products that can expand Ontario's export markets, and the key issues and challenges the industry must deal with in the years ahead.

INDUSTRY STRUCTURE

In terms of employment and the value of shipments, food processing is the most significant part of the food chain in Ontario. The food and beverages processing industry ranks second in Ontario (after transportation equipment manufacturing) in terms of value-added ($5.9 billion in 1984) and the value of shipments ($17.4 billion). With 84,000 people working in the industry, it is also a major employer, and that number has not changed appreciably in at least 15 years. The value of shipments has risen by almost 30 percent, and the level of employment has remained steady, despite a significant (40 percent) decline in the number of food processing establishments in the past decade and a half. Ontario's food and beverage processing industry is thus highly concentrated and, on average, more profitable than other types of manufacturing.

Foreign ownership of food processing companies stands at about 17 percent of sales and of beverage firms at 63 percent of sales. The ownership of food processing firms is important because it relates to Ontario's performance as a food exporter. Canadian-owned companies account for the bulk of Ontario's food and beverage exports, whereas the foreign-owned companies export much less relative to their sales in Canada. Overall, Ontario is a net importer of food, a fact that could take on added significance under a free trade regime with the United States. Under such an agreement, the protective tariff walls that encouraged foreign-owned companies to establish facilities in Canada to serve the Canadian market would come down, significantly altering the competitive dynamics of the industry. In some cases these foreign companies would find it much more economical to serve the Canadian market from their U.S. plants. In addition, as tariffs decline and marketing boards and market quotas are maintained Ontario food processors will be at a competitive disadvantage.

Food processing is an important source of manufacturing value-added for Ontario. Value-added in food and beverage processing has grown steadily over the past decade and is up by 27 percent since 1970. Value-added per person employed has risen by a similar amount, and Ontario's food processors compare favourably with those in other countries in terms of value-added per person.

However, the food and beverage processing sector is highly diverse, with some types of processing (particularly breweries, distilleries, cereals, and soft drinks) achieving much higher value-added per person than other segments. These differences are accounted for in large part by the extent to which the particular sector is dependent on raw materials as a significant input cost.

KEY COMPETITIVE FACTORS

Given its importance to Ontario's economic base, the competitive situation facing the industry, particularly under the proposed trade agreement, should be of concern to policymakers. Several key factors determine success in most food processing businesses: raw materials costs, processing costs, and the ability to secure a price premium through higher quality and brand awareness.

The Significance of Raw Material Input Costs

Raw material prices are perhaps the most significant factor affecting the competitiveness of the industry, given that a substantial portion of the industry is based largely on raw materials. Dividing the industry into food sub-segments—meat, dairy, confectionery, cereals, etc.—reveals that the segments where value-added is lower (those that are largely raw materials-based, such as meat, poultry, fruit, and vegetable products) account for about 70 percent of food processing shipments. The higher value-added segments, such as distillery, brewery, and bakery products, account for the remainder (See Exhibit III.1).

EXHIBIT III.1

ONTARIO FOOD PROCESSING INDUSTRY SHIPMENTS 1984

Raw Materials-Based Products*	$ Billions	Higher Valued-Added Products	$ Billions
Meat and Poultry Products	$3.4	Cereal Foods	$ .5
Fruit and Vegetable Products	1.5	Biscuits and Other Bakery Products	1.2
Dairy Products	2.5	Confectionery Products	1.0
Flour Industry	.5	Miscellaneous Food Products (snacks & pasta)	.3
Feed Industry	1.0	Distillery Products	.5
Vegetable Oils	.4	Brewery Products	.8
Tea and Coffee	.2	Soft Drinks Industry	1.0
Food Products (not elsewhere classified)	2.4	Wine Industry	.1
TOTAL	11.9		5.4

Total Shipments = $17.3 Billion

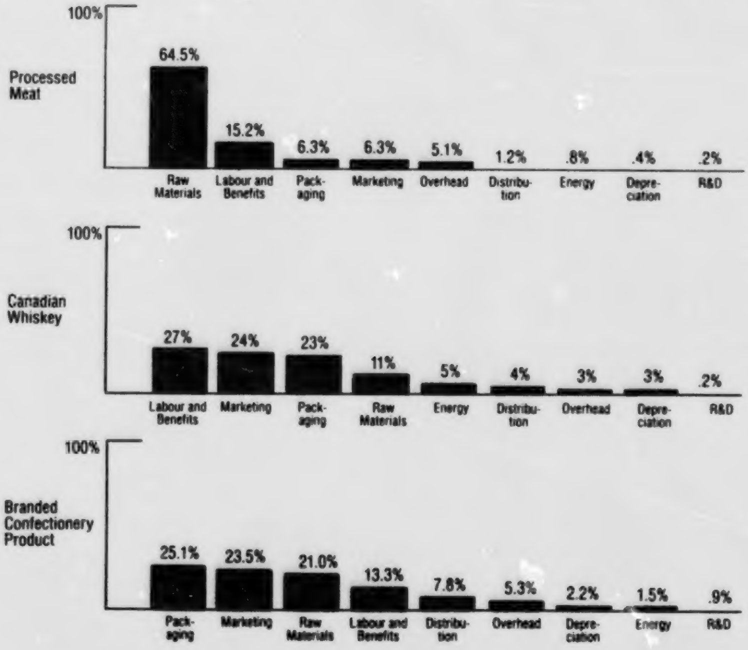
*Shipments to value-added ratio is greater than 2.4.
Source: Canada Consulting Group analysis based on Statistics Canada, Manufacturing Industries of Canada, Catalogue #31203.

In some industry sub-segments, such as meat, raw materials account for up to 65 percent of total input costs—far more than the labour, energy, and marketing costs required. In other segments, such as canned vegetables, raw materials account for 32 percent of costs, while in confectionery products, they constitute 21 percent (See Exhibit III.2). In general, the lower the percentage of raw material costs in total product costs the greater the scope for the producer to compete in another dimension. In whiskey and branded confectionery products, where marketing and packaging costs are almost half of total product costs, competition quite clearly focusses most importantly around marketing activities.

Prices of raw materials are determined in two ways: normal supply and demand or supply management in the form of marketing boards. For food products whose input prices are not

EXHIBIT III.2

COST STRUCTURE OF SELECTED ONTARIO PROCESSED FOOD PRODUCTS



Source: Canada Consulting and Telesis interviews with food and beverage processors, 1987.

governed by marketing boards, the prices paid by Ontario food processors are based on the U.S. price for the raw material, plus duty and freight. For those raw materials governed by supply-managed marketing boards, the board controls the final price of the product, whether by restricting the quantity through quotas or by influencing the price directly. This is significantly different from the way raw material prices are established in the United States—our major competitor—and in the European Economic Community, where farmers are subsidized directly through general revenues, and final prices to the processor and the consumer are not affected to the same degree.

These differences in how commodity prices are established are important for two reasons. First, most raw material inputs for food processing are higher in Ontario than in the United States. Tomatoes, for example, which are used in vegetable juices and soups, sold for 6 cents (Cdn.) a pound in Ontario in 1986 and 4.8 cents (Cdn.) in the United States. Turkey meat, used in turkey pies and soups, was $0.65 per pound in Ontario and almost $0.35 in the United States (See Exhibit III.3). Second, many of the food products whose raw material prices are governed by supply-managed marketing boards consistently show negative trade balances. These include such foods as dairy products and processed fruits and vegetables. By contrast, some of the products that are among Ontario's leading food exports—including whiskey and beer—do not use raw materials whose prices are controlled by marketing boards. In other words, those Ontario food and beverage products that are competitive in world markets do not generally use any inputs with prices controlled by marketing boards.

Ontario runs an overall trade deficit in processed foods; in 1985 it amounted to $600 million on total exports of more than $1 billion. In addition, many of its major products are protected by significant tariffs on imports. The trade situation can be attributed to a poor raw materials cost position and also to the fact that many foreign-controlled companies operating in Ontario do not export. Even the handful of Canadian-controlled companies in the industry (with a few exceptions) do not export more than 20 percent of what they produce. Raw material prices are a key factor in the industry's lack of competitiveness and its poor trade performance in most sectors.

Plant Scale and Processing Costs

In addition to raw materials costs, the cost of processing can also be a key competitive factor for the food processor. Processing costs are often a function of plant scale in many food processing business segments. In meat processing, for example, the cost

EXHIBIT III.3

RAW MATERIAL COST COMPARISON
Canada–United States
1986

Product	Key Raw Material Input	Ontario Cost (Cdn. Dollars)	U.S. Cost* (Cdn. Dollars)
Frozen Chicken Dinner	Broiler Chickens, Potato Flakes	50¢/lb, 6¢/lb	35.7¢/lb, 6¢/lb
Turkey Pie	Turkey	65¢/lb	34.5¢/lb
Turkey Noodle Soup	Turkey Meat, Flour	65¢/lb, 20¢/lb	34.5¢/lb, 12¢/lb
	Wheat	$243/metric ton	$198/metric ton
Tomato Soup	Tomato	6¢/lb	4.8¢/lb
Vegetable Juice	Tomato Juice	6¢/lb	4.8¢/lb
Cottage Cheese	Milk (Class 3)	44.2¢/hectolitre	28.5¢/hectolitre
Vanilla Ice Cream	Dairy Products, (Class 4 Ice Cream Mixes)	44.1¢/hectolitre	25.4¢/hectolitre

*U.S. costs are adjusted for exchange rate differential to compare with Canadian costs.
Source: Grocery Products Manufacturers of Canada and Canada Consulting Group Inc.

per unit falls roughly six percent when production increases from 60 to 110 head processed per hour.

When the scale of processing plants operating in certain food segments in Ontario is compared to that of their U.S. competitors, the Ontario industry appears sub-scale. In meat processing, an average Ontario plant slaughters 4,000 head per week, while a U.S. plant slaughters 20,000 head per week. For beer, the picture is similar. An Ontario plant produces 2.5 million hectolitres per year, whereas the optimal size to minimize costs is 4.5 million hectolitres per year (See Exhibit III.4). In a few packaged goods food subsegments, one additional work shift a week by a U.S. plant would be sufficient to satisfy the Canadian market for the same branded products.

Many U.S. processors could produce enough to serve the Canadian market with little additional effort or investment, both because the Canadian market is small relative to the U.S. market and because many U.S. plants have significantly underused capacity. The U.S. food and beverage industry has been operating below full capacity; capacity utilization was 79 percent in 1986, down from 84 percent in 1970.

The Slow Pace of Technological Change

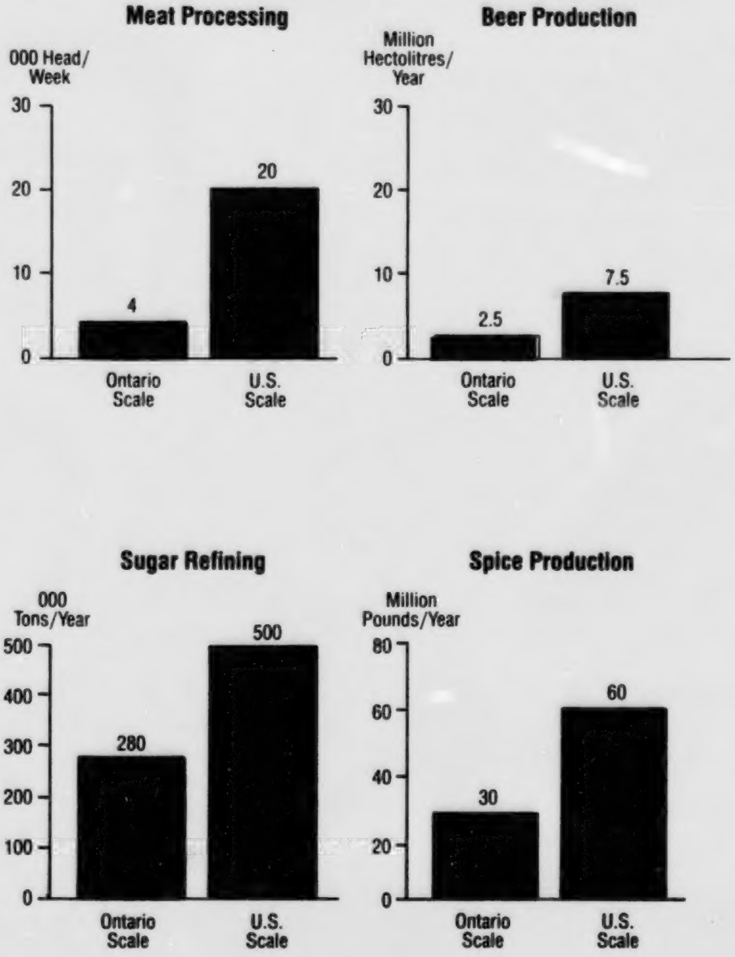
A third factor influencing competitiveness in the food processing industry is technological innovation and change. The level of technological innovation and the pace of change in food processing are low and lag far behind those of other Ontario industries. Research and development as a percentage of sales is 0.4 percent in food and beverage processing. This compares with the U.S. food industry, where companies such as General Foods and Quaker Oats spend just over one percent of sales in R&D.

New technologies such as modified atmosphere and aseptic packaging, fabricated fish and beef products, and the automation of carcass splitting and deboning could turn the art of making food into a more precise science, thereby giving the Ontario industry a competitive edge. However, the Ontario industry as a whole is not technologically innovative. Most technologies applied in the industry were invented a long time ago. Improvements have come in small, incremental steps. All of the major technologies been developed abroad: canning was developed in 1809 in France, irradiation was developed in the United States in 1943, and one of the most recent innovations—aseptic packaging—was developed in Sweden in the early 1960s. But more importantly, Canadian companies have not applied or utilized these technologies to any great degree.

One example of a major food technology originating in Canada

EXHIBIT III.4

FOOD PROCESSING SCALE COMPARISON



Source: Canada Consulting and Telesis Interviews, 1987.

EXHIBIT III.5

DEVELOPMENT OF HIGH-FRUCTOSE CORN SYRUP
CHRONOLOGY OF EVENTS

Time	Event	Place	R&D Time Span
1954	Hochster and Watson were first to discover an enzyme they called xylose, which can be used to produce high-fructose corn syrup. No hint of commercial potential; principal benefit of the discovery was increased understanding of role of sugars in biological cell metabolism. Publication of work was in medically-oriented biological journal, not usually read by industrial carbohydrate scientists	NRC, Ottawa	Basic Research
1957	Marshall and Kooi read Hochster and Watson, decided work warranted further investigation and wrote "Enzymatic Conversion of D-glucose to D-fructose", emphasizing the biological significance rather than its industrial importance	United States	
1960	Marshall was issued a patent on a process for converting dextrose to fructose using xylose isomerase	United States	
1969	Many patents still being sought on chemical methods of isomerization	United States	Technology Advancement
Late 1960s	Glucose isomerase research shifted to Japan and steady flow of publications emerged	Japan	
1963	Symposium on "Isomerase" held at the Annual Meeting of Agricultural Chemical Society demonstrating scientific importance attached to this class of enzymes by the Japanese	Tokyo, Japan	
1965	Tsumura and Sato obtained patent on use of stremptomyces	Tokyo, Japan	
1966	Y. Takasaki at Fermentation Research Institute obtained patents in Japan and U.S. to use inexpensive xylan rather than expensive xylose to produce the enyzme. Dr. Takasaki laid groundwork for commercialization of isomerization process	Chiba City, Japan	Industry Research To Commercialization
1967	U.S. firm purchased Takasaki know-how together with U.S. sub-licensing rights and brought process into commercial production in 1967	United States	

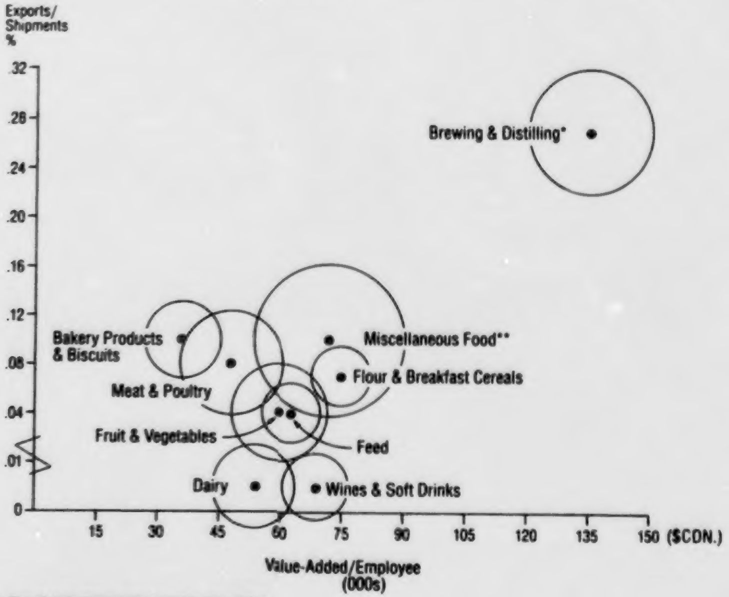
Source: J.P. Casey, "High Fructose Corn Syrup", *Die Stärke*, 1977 was high-fructose corn syrup, developed at the National Research Council in 1954. However, the technology was not exploited or commercialized in Canada. Rather, scientists in the United States and Japan saw its commercial potential and brought it into commercial production in 1967 (See Exhibit III.5).

THE SUCCESS OF HIGHER VALUE-ADDED PRODUCTS

For some Ontario food processing industry sub-segments—where competition is not dependent on relative raw materials cost—the competitive situation is much stronger. These products with higher value-added also represent Ontario's largest food processing exports. They are whiskey, with exports of $245 million in 1985 (Ontario's largest dollar export to the United States in the food and beverage category), pork at $93 million, and beer at $91 million. These products could serve as models for other

EXHIBIT III.6

VALUE-ADDED PER EMPLOYEE
AND EXPORTS TO SHIPMENTS RATIO
ONTARIO FOOD PROCESSORS, 1984



* Size of circle corresponds to relative value-added.
**Includes snacks, confectionery, oils, tea and coffee.
Source: Canada Consulting and Telesis data based on Statistics Canada.

parts of the food processing industry in the move to higher value-added products. Brewing and distilling has achieved, not only a high degree of value-added per employee or wealth creating capacity, but also a high degree of exports as a percent of sales (See Exhibit III.6). Several factors have contributed to the success of these products in the export market.

Canadian Whiskey's U.S. Market Penetration

Seagram has 15 percent of the U.S. market for distilled spirits, and Hiram Walker has eight percent. Factors in the success of these companies that have given Ontario-produced whiskey a competitive advantage in export markets include effective promotion and marketing, product differentiation, regulatory advantages, and superior technology. These firms also benefitted historically from the demise of the U.S. liquor industry during Prohibition.

Promotion and Marketing Both Hiram Walker and Seagram devote significant resources to promotion and are world-class marketers. At Hiram Walker, the emphasis is on worldwide marketing of new products that are profitable, with the accent on premium quality. Hiram exports more than 50 percent of its production. Seagram and Hiram Walker ranked first and second respectively in U.S. advertising spending by distillers in each year from 1981 to 1984. The cost structure of a Canadian whiskey product shows that packaging and marketing are large components of cost (See Exhibit III.2).

Product Differentiation Whiskey has a considerable product differentiation advantage over American bourbon, the closest substitute. Canadian whiskey has broad appeal among American whiskey drinkers. It accounts for 30 percent of total whiskey consumption in the United States and 12 percent of distilled spirits consumption overall. It is recognized as a distinctive product, and bottling in Canada affords an image of higher quality compared with spirits imported in bulk.

Regulatory Advantage Canadian whiskey has an advantage over U.S. products because Canadian exports are not subject to labelling requirements, while U.S. regulations require disclosure of ingredients on bottle labels. Canadian whiskey can also be aged in barrels, making it more palatable and lighter, while U.S. regulations forbid an aging process of this type.

Superior Technology As a result of the companies' significant export orientation, Canadian facilities are as modern as U.S. bottling operations and on a similar scale. Production facilities are state-of-the-art (Canada had the first computer-controlled distilling plant), and production runs on individual whiskey brands are sufficiently long to minimize line turnover costs. As a result, Canadian whiskey brands have a price advantage over the leading U.S. brands at both the low end and the high end of the market.

The Success of Pork

Pork, Ontario's second largest food export, has been successful in markets outside Ontario because it is a superior product, with an image of quality. Ontario produces more pork than it consumes, and 50 to 65 percent of Ontario pork production is now exported.

Superior Product Ontario produces a superior pork product. Our hogs are leaner and less fatty, a result of superior breeding techniques and technologies, such as electronic guns to measure fat content, that encourage leaner pork. The pricing system also encourages the production of leaner animals by placing more money in the hands of producers if their product contains less fat.

Quality Image Promotional campaigns have led the U.S. consumer to recognize that Ontario produces a leaner pork product. Consumers associate a leaner product with a healthier product, an advantage in today's health-conscious food market.

Beer's Niche in The U.S. Market

Beer is Ontario's third-largest dollar export. Canada remains second only to the Netherlands in terms of the dollar value of its beer sales in the U.S. market. Its success is attributable to better perceived product quality and successful exploitation of a special product niche. The American consumer will pay a price premium over domestic beer for an imported brand, but the price for Canadian brands is not as high as for a 12-pack of a European import. Canadian imports cost $7-8 per case of 12. Other foreign imports cost $10-12. U.S. domestic beers cost $6.

Product Niche Canadian beer fills a specialized product niche in the U.S. market. Canada's brewing process originated in Britain, which traditionally produced ales. The U.S. brewing process, however, originated in continental Europe, which traditionally produced lagers, and this is the nature of most U.S. domestic brands. Canadian exports therefore have been successful in fulfilling U.S. consumer demand for light ales, which are not produced in the United States.

Product Quality During the 1940s and 1950s, Canadian beer had a higher alcohol content than U.S. brands, and American consumers developed the belief that Canadian beer was stronger. The mythology attached to Canadian beer persists to this day, despite the fact that the Canadian beverage has only a slightly higher alcohol content (Canadian beer has 4.9-5.1% alcohol by volume, whereas U.S. beer has 4.6-4.7% alcohol by volume).

Heavy and well-positioned advertising by Canadian exporters has reinforced a superior quality image in the U.S. market.

ISSUES AND CHALLENGES

The success of Ontario exports of whiskey, pork, and beer illustrates the kinds of steps that are necessary to achieve competitiveness in food and beverage processing. Given the basic competitive factors governing success, the Ontario food processing industry will have to face a number of issues in the future. It will be particularly sensitive to a Canada-U.S. free trade regime and to increased competition from a U.S. industry that is now operating at less than full capacity and that could serve the Canadian market with little or no additional investment. The issues that the industry will have to address include the following:

- the fact that, under a free trade regime, packaged goods will be brought into Canada duty and tariff free, while marketing boards will still be controlling raw material prices and quantities within Canada, a situation that could spell disaster for some segments of the industry
- The extent to which companies and industry sub-segments can move to producing products with higher value-added
- The degree to which the industry can effectively use technology to improve processes and products, thereby giving it a competitive edge
- The concern that, under a free trade regime, many foreign-owned companies may find it more cost-effective to close plants here and export to Canada from the United States, especially those products with longer shelf lives
- The likelihood that, without tariffs on foodstuffs, many Canadian food processors may find it less costly to import raw materials from the United States.

A free trade regime would also be likely to prompt consolidation and restructuring in the food processing industry because of the competitive advantages to be gained through economies of scale:

- Some Canadian companies would likely expand capacity to enable them to take advantage of greater access to the much larger U.S. market
- Some might expand their operations in the United States, thus creating jobs there

- Certain parts of the Canadian industry, such as wine making, may be at significant risk once tariffs are eliminated under a free trade agreement because the tariff and government regulatory regime are all that protect their competitive position in the Canadian market.

With or without a free trade agreement, the Ontario food and beverage processing industry faces significant competitive challenges in the years ahead. However, a free trade regime with the United States will significantly alter the impact of those challenges and the urgency with which Ontario food and beverage processors must address them.

CHAPTER IV
THE CASE OF STEEL MANUFACTURING

The Canadian steel industry has always been world competitive. The industry's strength is attributable to a variety of factors:

- Rapid adaptation and enhancement of technological advances
- Maintenance of a relatively high (though cyclical) level of capital investment
- Easy access to raw materials at competitive prices
- Relatively high rates of capacity utilization
- Access to the U.S. market, with relatively few trade impediments and no significant competitive disadvantages
- Favourable currency exchange rates, particularly in recent years, providing a labour and materials cost advantage
- Corporate leadership that has generally remained focussed on the steel industry without the destructive diversifications imposed on U.S. steel companies.

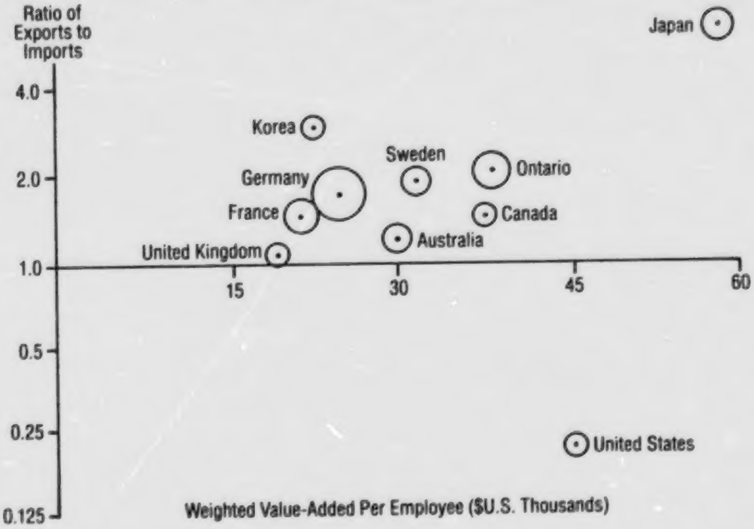
Canada's steel industry is concentrated in Ontario, which accounts for over 70 percent of Canadian raw steel capacity and employment and more than 80 percent of the value of shipments and value-added. In addition, the automobile equipment and machinery industries account for a significant proportion of the province's total manufacturing exports, and both are dependent on a competitive steel supply network. Ontario's steel industry therefore plays an important role in about 75 percent of the province's manufacturing trade. Over the last 15 years, employment in the steel industry has remained relatively constant at between 40,000 and 45,000, representing about five percent of the provincial manufacturing labour force.

The industry is an important contributor to the Ontario economy in terms of its trade balance and value-added per employee (See Exhibit IV.1).

In 1984, Ontario steel exports reached $3.2 billion, ranking third in the value of exports by manufacturing sectors. In terms of value-added, the steel industry ranked sixth. Internationally, the Canadian steel industry has a higher level of value-added per employee than all other countries except Japan and the United States. Furthermore, its ratio of exports to imports compares favourably with that of most trading countries.

EXHIBIT IV.1

IRON AND STEEL
STRENGTH OF MANUFACTURING STRUCTURE[1]



1. 1983 value-added data at 1986 exchange rates.
Note: Circle size is proportional to % of total manufacturing employment.
Source: Canada Consulting and Telesis analysis.

THE RELATIONSHIP BETWEEN STEEL AND AUTOS

The auto industry is a particularly important market for Canadian steel. The motor vehicles and parts industries and the construction industry account for just over half of domestic steel shipments. However, while the use of steel by other industries has remained steady in construction, stampings, pressings, and forging, for example, or declined in such areas as pipes and tubes, railway cars and track, the use of steel by the auto industry has grown as a proportion of total steel consumption (See Exhibit IV.2).

To a large extent, the current health of the Canadian steel industry reflects the health of the automotive industry. The auto industry's consumption of Canadian steel has grown even though much of the body stamping is carried out in the United States. By tailoring its products and level of service to meet the needs of the auto industry (for example, by emphasizing just-in-time delivery and implementing quality improvements) the Canadian steel

EXHIBIT IV.2

CANADIAN DOMESTIC USE OF STEEL
1981-86
(Percentage Of Total Shipments)

	1981	1984	1986
Motor Vehicles & Parts	16.8%	25.4%	26.1%
Construction	25.7%	22.0%	24.7%
Pipes & Tubes	20.0%	16.8%	13.9%
Wires & Fasteners	7.3%	8.4%	8.7%
Stampings, Pressings & Coatings	7.3%	7.3%	7.9%
Machinery	4.8%	4.4%	4.8%
Railway Cars & Track	4.6%	3.9%	2.2%
Natural Resource Industries	3.9%	2.8%	2.6%

Source: Statistics Canada, Company interviews by Telesis.

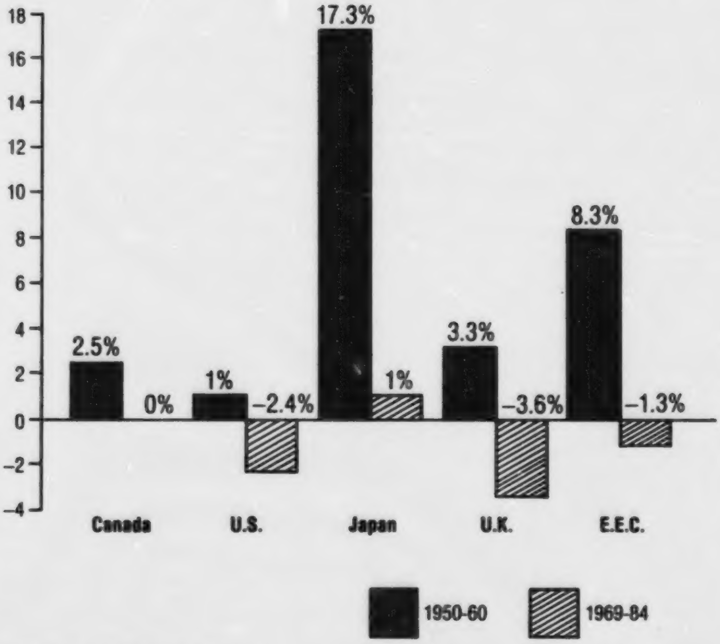
industry has been able to build a significant volume of sales to the auto industry. The steel industry is also attempting to build sales volume by capturing the business generated by the Japanese automakers' new Canadian facilities, possibly including body fabrication. Even Algoma Steel in Sault Ste. Marie, traditionally a producer of track, pipe, and heavy structural steel products, currently sells 30 percent of its production to the auto industry.

WORLD STEEL TRADE

Even if Canada maintains a favourable competitive position, it is not reasonable to expect that Ontario's steel industry will be able to improve its trade position dramatically through an increase in exports. Several factors limit the industry's expansion into export markets: worldwide steel consumption is showing no

EXHIBIT IV.3

GROWTH IN STEEL CONSUMPTION
(Compound Annual Percentage Rates)



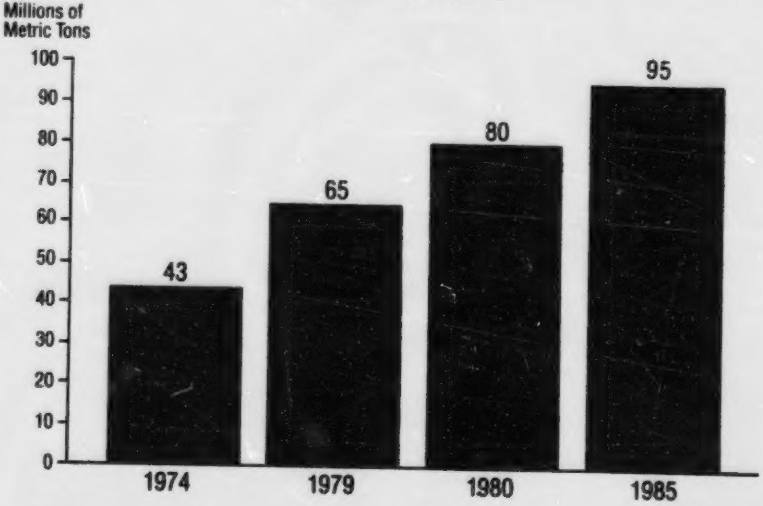
Source: U.S. Congressional Budget Office.

growth or negative growth; new, aggressive competitors have entered world markets; and international markets are becoming increasingly regulated in response to the new competitive environment. Since 1969, the growth in steel consumption by almost all major steel producing countries has been negative (See Exhibit IV.3). As a result, throughout the 1980s, there has been a worldwide glut of steel-making capacity.

Despite the overcapacity in developed countries, newly industrializing countries like Brazil, Korea, and Mexico have doubled their capacity in the past ten years (See Exhibit IV.4). They took advantage of the situation in developed countries, where inefficient mills based on outdated technology were still being operated, and built large, modern mills that are extremely competitive in the steel market. Lower wage rates, access to competitively priced raw materials, and subsidized and protected domestic markets enhanced their ability not only to acquire market share but also to drive many North American, European and Japanese producers out of the steel industry.

EXHIBIT IV.4

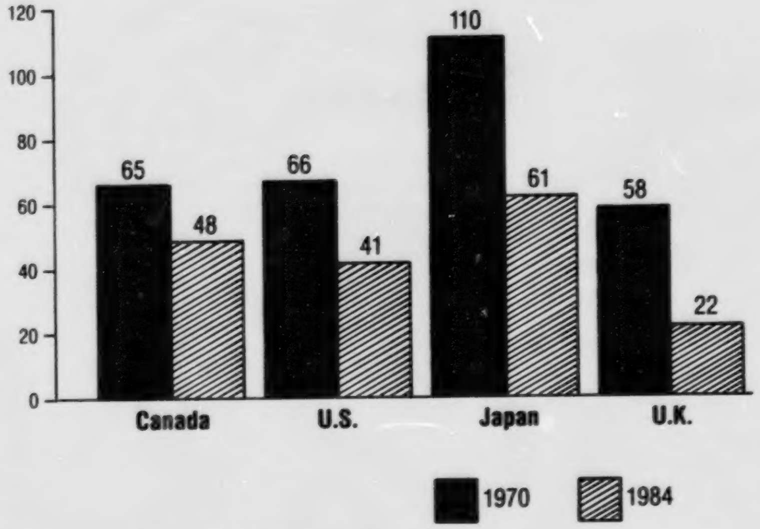
STEEL CAPACITY IN DEVELOPING COUNTRIES
1974-1985
(Millions of Metric Tons)



Source: World Steel Dynamics.

EXHIBIT IV.5

STEEL INTENSITIES OF SELECTED COUNTRIES
(Tons per $Million GDP)



Source: Canada Steel Committee on Access to the U.S. Market

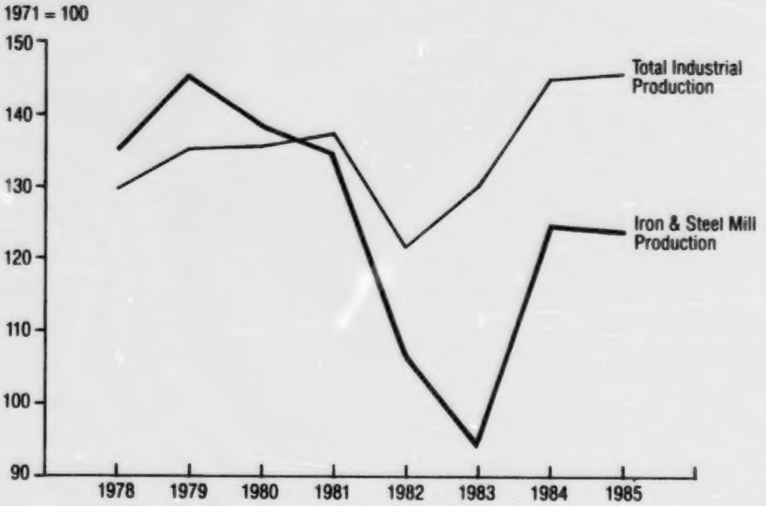
The continued decline in the use of steel relative to overall economic output in the major developed countries is placing additional stress on steel manufacturing in North America (See Exhibit IV.5). In Canada, for example, since 1981 the growth in the volume of steel production has lagged behind total industrial production (See Exhibit IV.6).

This relative slowing of growth in steel consumption in developed countries can be attributed to a number of factors:

- Developed countries have slowed the pace of steel-intensive infrastructure construction
- Advances in steel technology allow the use of lighter-weight, higher-strength steel to perform a given function
- Other materials, including plastics, aluminum, ceramics, and reinforced concrete, are increasingly being substituted where traditionally steel has been used

EXHIBIT IV.6

STEEL VERSUS TOTAL INDUSTRIAL PRODUCTION IN CANADA



Source: Canadian Minerals Yearbook.

- Automobiles use less steel, having been downsized in response to the rising cost of energy and consumer preferences.

The industrialized countries have reacted in various ways to moderate the effects of these changes on their steel industries. The application of Voluntary Restraint Agreements (VRA) by the United States developed from a safeguard action under Article XIX of the General Agreement on Tariffs and Trade (GATT), a United States "201 Action". That proceeding found serious injury on only five of the nine steel product categories reviewed. The resulting "President's Steel Program" reflected the major impact on one of its key industries and represented an attempt to buy time to permit restructuring of the industry. Prior to the announcement of the "President's Program", the Canadian government, with industry support, gave assurance that any restraints on other world suppliers "would not be exploited by Canadian Steel Producers". Since 1984 the U.S. has instituted VRAs with most major exporters (Canada is one exception) in an attempt to limit imports to 20.5 percent of the U.S. market. The

Canadian industry has attempted unofficially to limit its exports to the United States to three percent of the market. However, a rise to nearly four percent in 1986 brought threats of official export limits. As a result, the U.S. market is not likely to be a source of growth for Canadian steel exports regardless of the changes in the trade regime with the United States.

Worldwide overcapacity in recent years has led to a situation where the trading of steel in international markets has become highly regulated. Because capacity utilization is a key determinant of cost, this overcapacity has motivated producers to export at or below marginal costs so as to keep production levels up. The United States and European countries have reacted by erecting barriers (VRAs or import limitations) to protect their industries from the large-scale efficient steel facilities in the newly industrialized countries. At the same time, the markets of these new competitors are essentially closed to steel exports from the developed world. Canada has perhaps the most open market for steel in the world, but Canadian steelmakers can find no corresponding free markets for their products.

Ontario's steel exports have declined slightly since 1980 in absolute terms and substantially when considered as a proportion of total manufactured exports (See Exhibit IV.7). Nevertheless, although its steel trade is significant, Canada is not nearly as dependent upon exports as other major western steel producers. France and West Germany export 50 percent of their crude steel production and Sweden more than 60 percent, while Canada exports about 20 percent of production (See Exhibit IV.8). In fact, Canada has been able to maintain a relatively stable though modest (around $5 million) steel trade surplus since 1982 (See Exhibit IV.9).

CANADA-U.S. STEEL TRADE

The United States is Canada's largest trading partner, but imports into the United States are becoming increasingly restricted. Even under a free trade agreement, it is unrealistic to expect future growth in overall steel exports from Canada to the United States; instead, exports would likely be restricted to close to current levels. Some form of import constraint on steel mill products is expected to continue after the President's Steel Program expires on September 30, 1989. However, growth in the value-added of steel exports to the United States is possible, and most Canadian mills are emphasizing production of higher quality steel to obtain additional income within existing tonnage limitations.

About 20 percent of total Canadian steel production is

EXHIBIT IV.7

STEEL'S ROLE IN ONTARIO MANUFACTURING EXPORTS*

$1985 Billions

Product	1980		1982		1984		1985		1986	
	$	%	$	%	$	%	$	%	$	%
Transportation Equipment	$14.5	42%	$18.8	51%	$29.8	58%	$32.4	59%	$32.8	59%
Iron & Steel	3.8	11%	2.8	8%	3.3	6%	3.2	6%	3.1	6%
Machinery	3.6	10%	3.2	9%	4.0	8%	4.1	7%	4.3	8%
Chemicals	2.4	7%	2.2	6%	2.2	4%	2.3	4%	2.5	4%
Paper Products	2.3	7%	1.9	5%	2.3	4%	2.3	4%	2.3	4%
Other										
Total Manufacturing	$34.3	100%	$36.7	100%	$51.5	100%	$55.1	100%	$55.3	100%

*Includes re-exports.
Source: Statistics Canada.

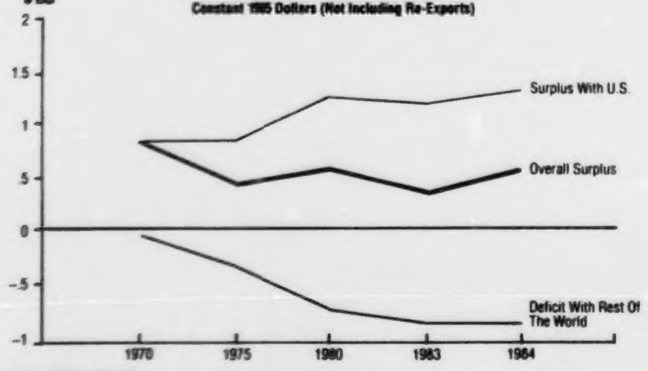
EXHIBIT IV.8

STEEL EXPORTS AS A PERCENTAGE OF CRUDE STEEL PRODUCTION
1985

	Total Production (Million Tons)	Exports %
Japan	105.3	29.7%
United States	80.1	1.0%
West Germany	40.5	49.6%
Italy	23.9	33.6%
France	18.8	50.0%
United Kingdom	15.7	31.2%
Canada	**14.6**	**17.6%**
Sweden	4.8	62.5%

Source: Organization for Economic Cooperation and Development

EXHIBIT IV.9



Source: Statistics Canada

exported to the United States; this amounts to about three percent of U.S. steel consumption. Canada is also the largest customer for U.S. steel exports. Canada receives about 23 percent of total U.S. exports, which represents 0.3 percent of U.S production and five to six percent of Canadian consumption.

Major raw materials are also heavily traded between the United States and Canada; joint venture iron ore mines are common in both countries. For coal supplies, major Canadian mills rely on Appalachian mines they own or with whom they have long-term supply relationships.

The Canada-U.S. steel link is strengthened by geography; many Ontario mills are strategically located to serve major U.S. steel markets. The two countries also share a similar steel market structure; major mills tend to rely heavily on sales to the construction and automobile industries.

The Canadian steel industry is fully competitive with U.S. steelmakers. Only Japan exports more steel to the United States than Canada does, but Canada's trade has grown, whereas exports to the United States by other major producers have dropped (See Exhibit IV.10). Consequently, uninterrupted access

EXHIBIT IV.10

U.S. IMPORTS OF STEEL MILL PRODUCTS
(Million Net Tons)

Country	1985	1986	% Change
Japan	6.0	4.4	–27
Canada	2.9	3.2	+10
West Germany	2.4	2.0	–17
Korea	1.9	1.5	–21
France	1.6	1.2	–25
Brazil	1.7	1.0	–41
Total	24.2	20.7	–15

Source: American Iron and Steel Institute.

to the U.S. markets is vitally important to the continued strength of the steel industry.

Every Canadian steelmaker asserts that it could increase its U.S. exports if it were not constrained by the pledge to maintain them at the 3.2 percent level. Currently, almost 25 percent of Canadian sales are represented by U.S. exports (not including re-exports or exports of products made of steel).

FACTORS IN COMPETITIVENESS

Competitiveness in the steel industry is driven by four major considerations:

- Wage costs
- Material costs
- Capacity utilization rates
- The level of investment needed to maintain production technology and quality levels.

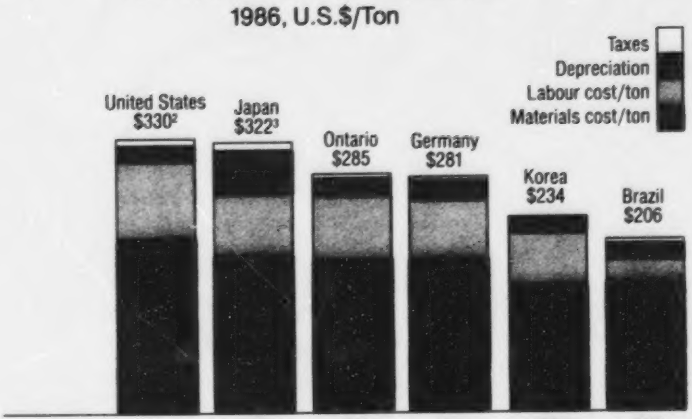
A comparison of costs at typical mills in several countries shows Ontario as competitive with other nations (See Exhibit IV.11). At the same time, this comparison of operating steel mills reveals several important messages about competitiveness. First, Canada's currency exchange rate plays an important role in maintaining its competitiveness relative to other countries. Second, Japan's low capacity utilization rate and the high value of the yen have significantly impaired its competitiveness, despite its technological leadership. A third observation is that steel mills in developing countries still show low efficiencies, but these are overcome by high utilization rates, low wages, and an ability to source raw materials at low prices. Finally, a relatively efficient mill can become uncompetitive if it is tied into high-cost material contracts, as shown by the U.S. mill described in Exhibit IV.11.

The success of Canada's steel industry results largely from the existence of strong companies with an ability to compete internationally. Yet the internationally significant technological commitments made by individual companies may be masked when the performance of the sector as a whole is reviewed. Dofasco, for example, was a leader in basic oxygen furnace technology. From financial hardship, Algoma has emerged with one of the world's most modern pipe and tube mills, which in 1989 will become the largest mill in North America, casting 100 percent of its product continuously. Stelco's Lake Erie works, which began production in 1983, is the most modern integrated mill in North America. Costeel pioneered the mini-mill concept at Lake Ontario Steel in

EXHIBIT IV.11

COMPARATIVE COSTS TO PRODUCE HOT ROLLED STEEL PRODUCTS[1]

1986, U.S.$/Ton



Capacity Utilization	75%	60%	80%	80%	100%	95%
Man Hours/Ton	4.0	4.6	4.5	4.4	6.4	6.5
Wages/Hour	23.0	15.88	17.25	15.45	3.28	3.50

1. Based on interviews with representative companies. 2. Does not include marketing or overhead costs.
3. Japan's man hours per ton is relatively low because capacity utilization is low.
Source: World Steel Dynamics

Whitby, then exported the concept through major investments in the United States and England.

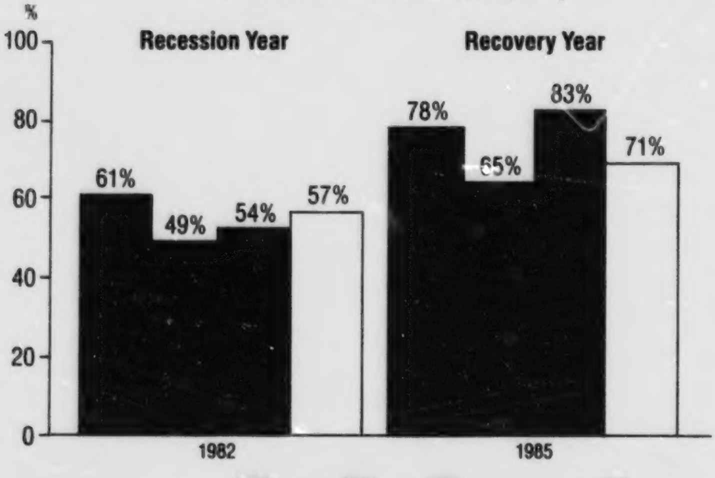
Although it still maintains a strong international position, some aspects of Canada's competitive position have been eroded in recent years by several international trends. The growth of raw material industries in countries such as Brazil has meant that many North American manufacturers are locked into supply arrangements with prices sometimes double the world's spot market price. Newly industrialized countries such as Korea have built highly efficient mills that use low wage labour. The large U.S. integrated mills, in decline since the early 1970s, have been restructuring, using bankruptcy reorganization, Japanese joint ventures, and rationalization of excess or obsolete capacity to re-establish competitive positions. Relatively efficient mini-mills, based on electric furnaces, labour-efficient technologies, the use of scrap steel, and lower labour costs, have also become a major factor in U.S. steel markets.

Canada's major mills are completing a new cycle of major investments, focussing on quality and productivity improvements rather than additions to capacity. As a result, Canadian industry performance should improve markedly within the next few months. Dofasco has inaugurated new continuous casting facilities for 50 percent of its production. Additional casting facilities just completed at Stelco's Hilton works, IPSCO, and Algoma will bring Canadian production to at least 75 percent continuous casting in 1988, compared to less than 40 percent in 1986. Stelco has effectively retired its open-hearth capacity, with the result that all of Canada's production steel will come from basic oxygen and electric arc furnaces.

Canada's competitive position in steel has been helped by having a comparatively higher capacity utilization rate than that of the United States, West Germany (in 1982), or even the EEC as a whole (See Exhibit IV.12). Capacity utilization in the United States and Canada was roughly equal in 1979, but rates in the U.S. industry declined more rapidly than in Canadian steel companies and have not recovered as quickly. Furthermore, Canada's steel industry has followed a strategy of investing enough to remain technologically ahead of the U.S. steel industry, even

EXHIBIT IV.12

CRUDE STEEL PRODUCTION
% Utilization Of Effective Capacity



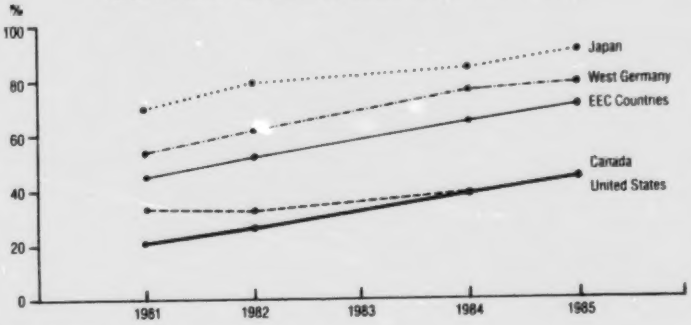
Source: OECD.

though it has not always matched modernization levels in Japan and Europe.

From the point of view of technological competitiveness, Canada has lagged behind Europe and Japan in adopting continuous casting methods, but it has advanced ahead of U.S. steelmakers in this regard. Canada has also lagged behind other major steel producing countries in phasing out open-hearth furnaces in favour of basic oxygen processing, but it has now moved ahead of the U.S. steel industry (See Exhibit IV.13).

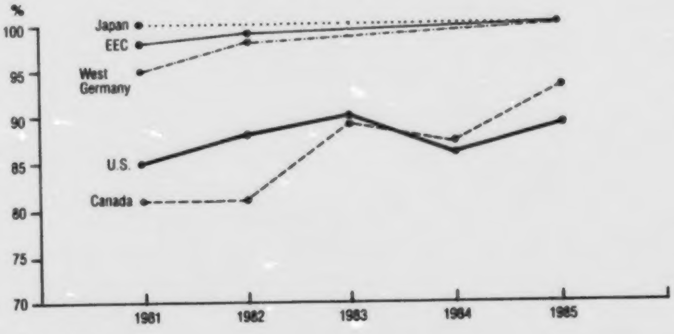
EXHIBIT IV.13

PERCENTAGE OF RAW STEEL PRODUCED BY CONTINUOUS CASTING



Source OECD

PERCENTAGE OF RAW STEEL PRODUCED BY BASIC OXYGEN PROCESS
(Excluding Electric Furnance Production)



Source: OECD

EXHIBIT IV.14

CAPITAL INVESTMENT IN STEEL IN RELATION TO RAW STEEL PRODUCTION
$U.S./Metric Ton

Country	1980	1981	1982	1983	1984	1985
Canada	31.10	40.90	41.70	12.30	12.10	34.00
United States	33.40	31.50	62.40	42.10	28.90	21.10
Total EEC	18.60	19.40	23.10	22.30	18.70	23.10
Japan	25.20	35.40	38.50	38.50	25.30	28.30

Source: OECD.

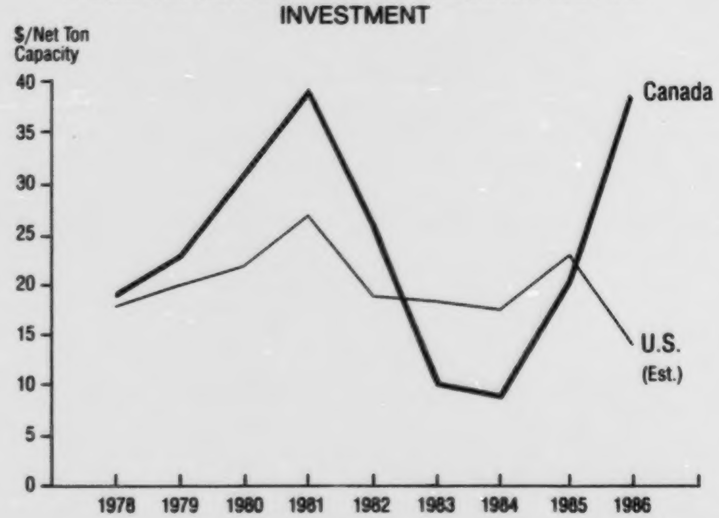
Canada's capital investment in steel facilities has compared favourably with that of other major western steel producers during the 1980s (See Exhibit IV.14). Except during the 1982 recession, Canada has consistently invested more than the U.S. steel industry in relation to existing production capacity (See Exhibit IV.15). If U.S. and Canadian steel industry capital investment for the past eight years is compared to the production capacity remaining in 1986, Canada outspent the United States by more than 13 percent.

Canada has been a leader in mini-mill electric furnace technology, but has not shifted as large a percentage of steel production to electric furnaces as U.S. producers have.

Although the structure of Canada's steel industry has remained relatively stable since World War II, the U.S. industry has undergone rapid change in the past decade. Production by major integrated mills has shrunk to less than 50 percent of U.S. production, compared to 65 percent in the early 1970s. Mini-mills have emerged as a highly profitable segment of the industry, and reconstituted bankrupt mills have emerged as a new segment. The rationalization of the U.S. steel industry has seen mini-mills gain-

EXHIBIT IV.15

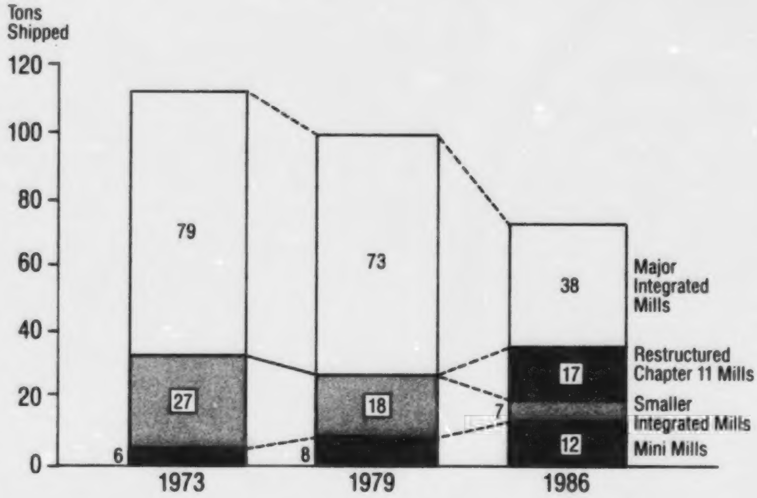
CANADIAN VERSUS U.S. STEEL INDUSTRY CAPITAL INVESTMENT



Source: Telesis, based on Canadian Minerals Yearbook, Statistics Canada, U.S. Department of Commerce, AISI.

EXHIBIT IV.16

THE RESTRUCTURING OF THE U.S. STEEL INDUSTRY



Source: World Steel Dynamics.

ing an increasing market share in a shrinking market, and the emergence of reconstituted bankrupt mills as a new segment (See Exhibits IV.16 and IV.17).

Reconstituted bankrupt mills have several advantages over established mills, a fact that could have implications for the future competitiveness of the Canadian steel industry. Some of these advantages include:

- Renegotiated labour contracts, which provide an advantage of up to 25 percent in the total package of wages and benefits
- Increased flexibility in work assignments
- Cancellation of long-term material supply agreements and an ability to buy on international spot markets at significant savings
- Possible renegotiation of utility rates and debt service payments.

ISSUES FOR THE FUTURE

Canada's competitive position is affected by continuing trends influencing the development of the world steel industry. The

EXHIBIT IV.17

ESTABLISHED VERSUS RECONSTITUTED MILLS IN THE U.S.
$U.S./Ton Shipped

	Major Mill	Reconstituted Mill	Reason
Operating Rate	75%	80%	
Man hours/Ton Shipped	7.0	5.8	
Wages & Benefits	$157 (22.50/hour)	$96 ($16.50/hour)	Renegotiated Labour Contracts
Iron Ore	77	61	Spot Market Prices
Coal	52	47	Spot Market Prices
Energy	63	58	Renegotiation
Other Materials; SG&A	96	92	Overhead Savings
Operating Cost	$445	$354	

Note: This comparison is of higher-cost mills and includes average costs for all products. Earlier multi-country comparison in Exhibit IV.11 was for hot-rolled product only.
Source: World Steel Dynamics.

growing demand for higher quality steel is driven by increasing automation in the manufacturing sector, particularly in the automotive industry. The U.S. steel industry is completing its rationalization, which will make it more difficult for Canadian mills to compete, even though exchange rates have made it easier to stay ahead of the game in recent years. Increasing low-cost production in newly industrializing countries will ensure maintenance of protectionist barriers in most developed countries. Raw materials will continue to be a competitive advantage for countries with the flexibility to use new sources in developing countries.

Several key issues must be addressed if the success of the steel industry in Canada is to continue. Uninterrupted access to the U.S. market is critical in light of the fact that other international markets will remain protected and that almost a quarter of Canadian steel is exported to the U.S.

Canadian automotive policy is another key to keeping the Canadian steel industry healthy. The establishment of Japanese automotive plants could provide important new domestic market opportunities for the Canadian auto parts industry, which is the steel industry's single most important customer group. The quality and productivity demands placed on the steel industry will require a business climate conducive to continued investment in plant and equipment to meet those demands. Finally, a strategy of helping Canadian producers to increase the value-added of their products may be the only way to make significant improvements in Canada's trade position.

CHAPTER V
AUTOMOTIVE MANUFACTURING

COMPETITIVE DYNAMICS

The world automotive industry has experienced a significant realignment in the past decade and a half. The Japanese auto industry has emerged as a significant challenge to the traditional North American and European industries. The success of the Japanese automakers has been the result of a combination of factors that gave them a strong competitive position in terms of both the cost and the quality of their products. However, it was the influence of OPEC that initially allowed the Japanese to establish themselves in the North American market. The rapid increase in the cost of oil in the 1970s created a large demand for small, fuel-efficient automobiles, which General Motors, Ford, and Chrysler (the Big Three) did not manufacture in large numbers at that time; it was a demand that could be satisfied only by the Japanese auto industry.

The Vehicle Assemblers

In response to the Japanese challenge the North American automotive industry has undergone rapid industrial renewal. North American auto assemblers, driven by competitive Japanese and European manufacturers, have rediscovered the importance of product quality, the need to be responsive to the market, and the necessity of continual investment in process technology. In some product lines, especially mid-size and compact cars, North American manufacturers have tackled the Japanese competition head-on. But they have not been as aggressive in certain other market segments, particularly sub-compacts. Instead, they have chosen to source some of these products offshore, resulting in an outflow of capital investment and jobs from North America.

The development of Japanese and, more recently, South Korean auto assemblers has dramatically changed the international automotive industry. Previously, North American manufacturers controlled by far the largest share of the market. Now their share is continually threatened by Asian manufacturers. The North American auto manufacturers are faced with not only protecting their existing share but, through improved quality and cost competitiveness, trying to grab back the portion of the market they have lost. Part of the strategy is to develop new products and rebuild assembly plants around advanced technologies and new forms of work organization. General Motors, Ford, and Chrysler have invested heavily in modernization, and now some of their most modern facilities are in Ontario. In addition, Japanese automakers, including Toyota, Honda, and Suzuki, have invested in the Province, and they (except Suzuki) and others have built in the U.S. as well. However, all the new investments in North American assembly plants have also led to over capacity. This means that the prospect of further restructuring lies ahead, with some plants being closed rather than modernized.

Although the North American industry achieved a certain amount of prosperity during the mid-1980s, what is not clear is whether that recovery in profits was merely a respite in the inevitable restructuring of a mature manufacturing sector or a sign that the industry had truly regained competitiveness.

The Ontario vehicle assembly industry has experienced a significant level of investment in rebuilding both in new plant and equipment. Consequently, it is well positioned to weather the coming wave of restructuring. But the Ontario-based automotive assemblers will have to make strides in quality and productivity if the province is to hold its current position and compete strongly as a location for the next round of vehicle assembly investment.

Parts Manufacturing

The competitive dynamics are somewhat different in the other part of the automotive industry—parts manufacturing. In Ontario's automotive parts industry, the conditions for competitive success are shifting rapidly. Canadian-based parts companies face severe pressure from Japanese and European parts manufacturers entering the North American market on the strength of their home-base ties with foreign vehicle manufacturers. The foreign parts companies are prepared to forgo short-term profits in order to gain a share of the market supplying the North American vehicle assemblers.

At the same time as the available share of the parts market is being shrunk by the new entrants, competitive pressures are also intensifying on the cost and quality fronts. Parts companies that want to be competitive are having to take on new roles in the product development chain and meet tougher cost and quality targets.

Where previously they built parts to meet specifications set by the assemblers, parts companies are now called on to take greater responsibility for research and development and part design. This in turn has led to consolidation as companies have sought the scale necessary to fund R & D efforts. For many companies, it has proved difficult to build product design capacity; the necessary technological skills and experience in integrating product development and manufacturing simply have not been needed until now.

These same competitive pressures have meant technological change in the workplace. Greater production automation, together with changes in the management environment, are demanding new skills on the part of managers and workers alike.

Competitive restructuring will only increase in the Ontario automotive parts industry. Under these conditions, the quality of management and the skill of the workforce can make a difference, and building sufficient scale will be crucial to success. Those firms that can adopt the new technologies and production management methods will widen their edge over their competitors and survive in the new competitive environment.

CANADIAN INDUSTRY STRUCTURE AND PERFORMANCE

Canada is the sixth largest assembler of cars and trucks in the world. The automotive industry, including both vehicle assemblers and parts manufacturers numbering about 500 in total, is the largest manufacturing sector in Canada, employing close to 130,000 people. This sector accounts for about 15 percent of manufacturing shipments, 60 percent of all manufactured exports, and seven percent of manufacturing employment. Vehicle assembly accounts for $26 billion of the $37 billion in shipments by the Canadian industry, with parts manufacturing accounting for the remainder. Among the independent parts manufacturers, 12 multinational equipment suppliers account for about 20 percent of the total output of original equipment (OE) parts. The remainder is supplied by approximately 450 firms, including the parts manufacturing carried on by the Big Three.

Canadian motor vehicle production peaked in 1985 at approximately 1.9 million units but has since declined (See Exhibit V.1). Canadian facilities were the sole North American source for certain medium and large passenger cars, such as the rear wheel drive Pontiac Grand Prix, Pontiac 6000 STE, Cutlass Supreme, Crown Victoria, and Grand Marquis, as well as for Chrysler's highly popular mini-vans. The high 1985 production level appears to be the result of cheaper oil, which contributed to a demand for larger automobiles in the United States. In addition,

EXHIBIT V.1

CANADIAN MOTOR-VEHICLE PRODUCTION
1978-1987 (000 Units)

Year	Passenger Cars	% Change	Commercial Vehicles	% Change	Total	% Change
1978	1,140	—	678	—	1,818	—
1979	988	(13.3)	644	(5.0)	1,632	(10.2)
1980	847	(14.3)	527	(18.2)	1,374	(15.8)
1981	806	(4.8)	524	(0.6)	1,330	(3.2)
1982	794	(1.5)	448	(15.5)	1,242	(6.6)
1983	940	18.4	547	22.1	1,487	19.8
1984	1,023	8.8	807	47.5	1,830	21.8
1985	1,077	4.7	856	6.5	1,930	5.5
1986	1,062	(1.4)	793	(7.9)	1,854	(4.1)
1987	810	(23.7)	826	4.2	1,636	(11.8)

Source: Ward's Automotive Reports and Motor Vehicle Manufacturers Association.
Notes: (1) Figures in brackets show negative change.
(2) Large increases in truck production in 1983 and 1984 reflect production of Chrysler's mini-vans, which are counted as trucks for statistical purposes.

there was healthy North American demand for G.M.'s Oshawa-built mid-size cars, and Ford's Tempo and Topaz models built in Oakville.

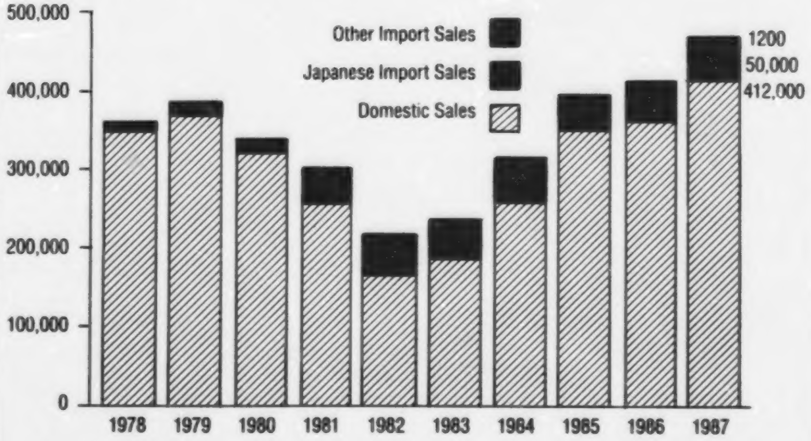
The production of commercial vehicles in Canada in 1986 totalled approximately 800,000 units, a 7.9 percent decrease relative to 1985 production (See Exhibit V.1). In terms of commercial vehicle production, Chrysler continues to be the leader, largely because of the popularity of its mini-vans and multi-purpose vehicles made in Windsor. Truck sales for 1987 reached a record of 463,239 units, up about 10 percent from 1986. General economic growth and activity account for sale increases in this market segment, and it is expected that the development activity now taking place will continue (See Exhibit V.2).

Market shares have remained constant for 1987, with North American-built trucks at 87.9 percent and imports at 12.1 percent. The entry of new domestically produced light trucks, mini-vans and pick-ups were instrumental in holding the import penetration level at about 12 percent during 1984-86. This trend continued in 1987, with imports capturing only about 11.3 percent of this market.

The Canadian market share for automobiles manufactured by North American assemblers including Japanese-owned facilities

EXHIBIT V.2

COMMERCIAL VEHICLE SALES IN CANADA
1978-87



Source: Ward's Automotive Yearbook, 1987.

EXHIBIT V.3

PASSENGER-CAR SALES IN CANADA
1978-1987 (000 Units)

Year	Domestic Sales	Total Import Sales	Total Import Market Share (%)	Japanese Import Sales	Japanese Market Share (%)	Total Sales
1978	816	173	17.5	113	11.4	989
1979	864	139	13.9	80	8.0	1,003
1980	741	191	20.5	138	14.8	932
1981	647	257	28.4	208	23.0	904
1982	489	224	31.4	178	25.0	713
1983	625	218	25.9	177	20.9	843
1984	725	246	25.3	171	17.6	971
1985	795	342	30.1	199	17.5	1,137
1986	762	329	30.2	198	18.1	1,091
1987	702	364	34.2	243	22.8	1,065

Source: Statistics Canada, 1988.

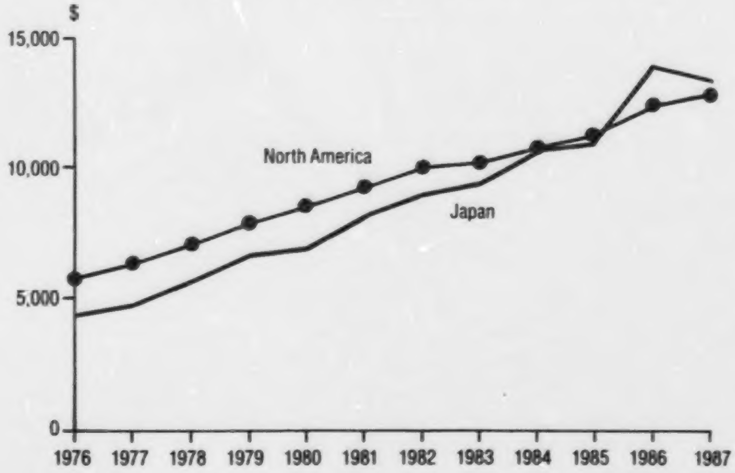
decreased from 69.8 percent in 1986 to 65.8 percent in 1987 (See Exhibit V.3). This decrease in market share is the result of aggressive competition by foreign automakers, which has resulted in a continued increase in import penetration from 30.1 percent in 1985 to 34.2 percent in 1987. This increasing level of import penetration does not appear to be affected by the average price of Japanese cars, which is now higher than that of North American cars (See Exhibit V.4). Meanwhile, captive imports (automobiles manufactured offshore and purchased by one of the Big Three) are accounting for an increasing share of total sales (See Exhibit V.5). This represents one of the Big Three's responses to competition in the sub-compact market segment. The others include the joint ventures for the manufacture of foreign-designed vehicles in cooperation with offshore assemblers (like the G.M./Suzuki facility in Ontario) and the development of a domestic sub-compact program such as G.M.'s Saturn project.

CANADA'S TRADE POSITION

The Auto Pact has played a dominant role in the development of the Canadian automotive industry. The Pact provides for

EXHIBIT V.4

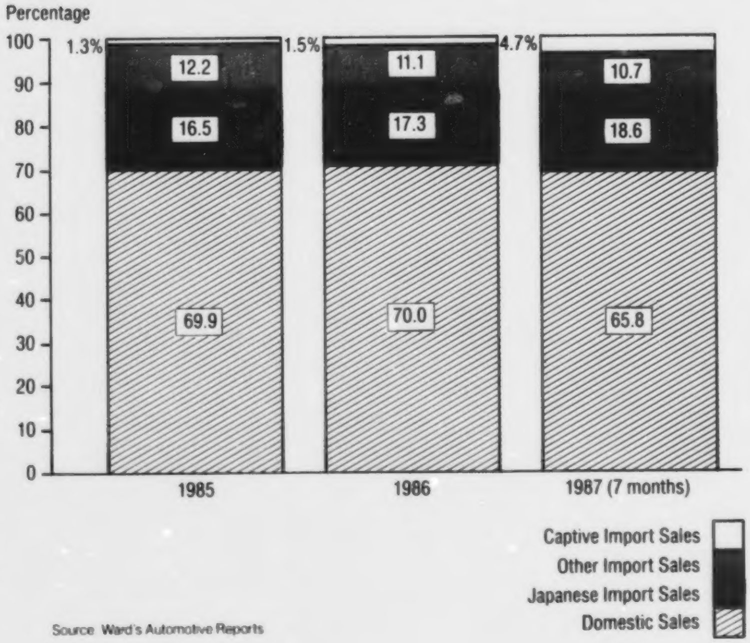
AVERAGE PRICES OF PASSENGER CARS BY ORIGIN



Source: Ward's Automotive Yearbook, 1987

EXHIBIT V.5

DISTRIBUTION OF PASSENGER CAR SALES IN CANADA
1985-87



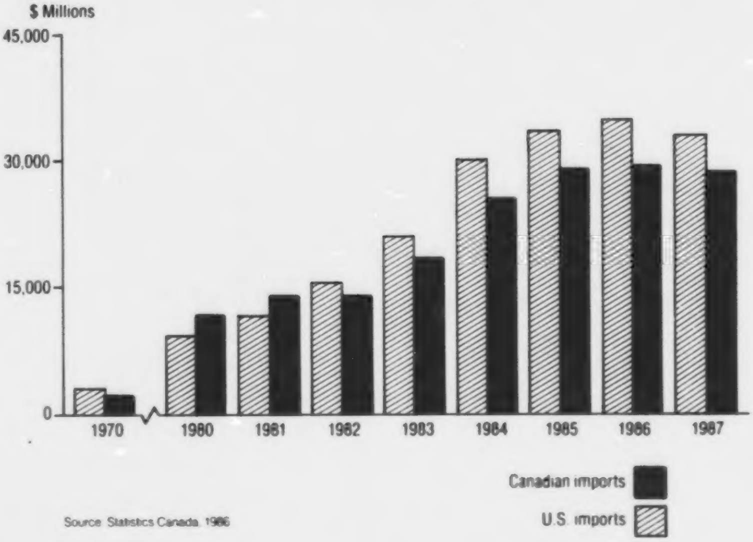
Source: Ward's Automotive Reports

managed trade between the United States and Canada in original equipment parts and in all but specialized types of newly manufactured vehicles. It excludes trade in aftermarket parts and accessories, tires and tubes, batteries, and used vehicles. Certain safeguards signed by the automakers participating in the pact guaranteed Canada a specific level of assembly activity and value-added relative to vehicle sales activity in Canada. Probably the greatest significance of the Pact is that it has served to rationalize production of vehicles and parts in the United States and Canada.

The Pact is largely responsible for the growth in Canada-U.S. trade in automotive products from $6.3 billion in 1970 to $63.7 billion in 1986 (See Exhibit V.6). In 1986, Canada posted a $5.3 billion automotive trade surplus with the United States. That was down 3.9 percent ($213 million) from the 1985 surplus of $5.5 billion, and the declining trend continued in 1987 with a trade sur-

EXHIBIT V.6

CANADA-U.S. TRADE IN AUTOMOTIVE PRODUCTS
1970-1986
Reconciled Basis (Annual data)



Source: Statistics Canada, 1986

plus of $3.9 billion, down 26 percent ($1.4 billion) from 1986.

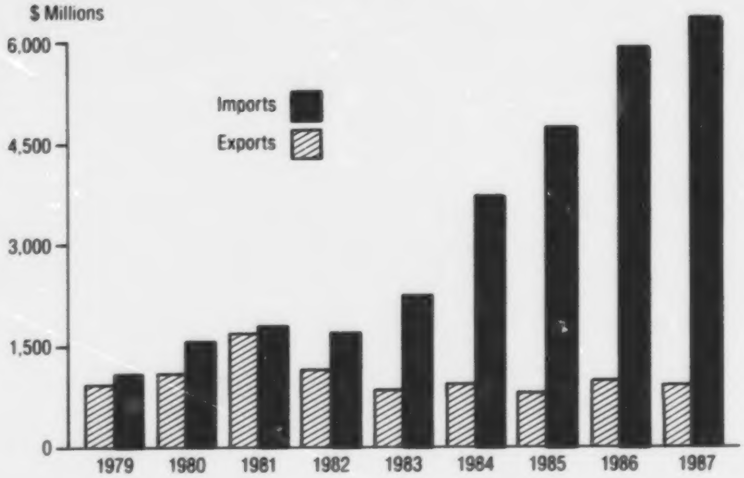
Except for the 1970-72 surplus of $446 million, Canada experienced recurring trade deficits in automotive products between 1965 and 1981. The cumulative deficit during that period amounted to $14.7 billion. However, Canada now has a cumulative surplus of $2.3 billion for the period 1965-1985. This surplus has occurred since 1982 as a result of several factors: the specialization of Canadian assembly facilities in certain higher-priced models, the lower value of the Canadian dollar, and the relative strength of the U.S. economy.

Canadian exports of automotive products grew by only 2.5 percent to $35.3 billion in 1986, after a jump of 12.5 percent in 1985. Imports of automotive products rose by 6.2 percent to $35.1 billion in 1986, following an increase of 19.7 percent in 1985. However, the high level of vehicle imports and increasing level of parts imports have increased the trade deficit in automotive products with overseas countries (See Exhibit V.7).

Canada's total imports of non-U.S. parts grew from $262 million in 1978 to $1.8 billion in 1986 and were projected to reach

EXHIBIT V.7

CANADA-OVERSEAS TRADE IN AUTOMOTIVE PARTS
1979-1987



Source: Statistics Canada Daily, March 27, 1987.

more than $2 billion in 1987. Consequently, although Canada is enjoying a healthy trade surplus with the United States, the impact of foreign import penetration is eroding its positive worldwide trade balance.

COMPETITIVENESS OF VEHICLE MANUFACTURERS

When sales were on the increase, manufacturers were investing considerable sums in modernizing plant and equipment. Now, with sales levelling off, North American vehicle manufacturers are continuing to make major efforts to control fixed and variable costs in order to improve their competitiveness. Although the cost gap between North American and foreign vehicle manufacturers, particularly the Japanese, is closing as a result of significant efforts on the part of the Big Three, foreign manufacturers continue to lower their costs to maintain competitiveness. They are often in a better position to control costs because they are building new plants at new locations, they have young work forces not requiring retraining, and they have few employees of pensionable age. Recently, however, currency exchange rates–in particular the revaluation of the yen–have increased the price of Japanese products, providing a window for the Big Three to regain some market share.

The Big Three achieved some improvement in productivity between 1981 and 1984, but since then levels have not improved as significantly. In the future, G.M., Ford, and Chrysler have staked their hopes for significant productivity improvement on the adoption of new work methods and technological processes such as computer-aided design and manufacturing, robotics, modular assembly, and just-in-time inventory control. For example, the G.M. truck plant in Oshawa was producing 45 units per hour prior to the application of a new automated production system. Once converted, its production rose to 60 units per hour with essentially the same work force.

COMPETITIVENESS OF THE PARTS INDUSTRY

Geographically the Canadian automotive parts industry is concentrated in southern Ontario, with 90 percent of its production dependent on exports to the United States. Over the last few years a greater proportion of the parts industry has become Canadian-owned and a higher percentage of parts are being sold directly to Canadian assembly operations. Although exports of Canadian automotive parts set a new record in 1986, with a value of almost $12 billion, this represented only a 1.5 percent increase over the value of shipments in 1985. Parts shipments in total also appeared to have levelled off, increasing in 1986 by only 0.6 percent over 1985. The range of products produced by the parts sector includes both high-value items, such as truck axles and engine parts, to lower-end routine components.

Canadian-owned parts manufacturers are extremely competitive in cross-border trade. They produce high-quality products, and a greater proportion of these companies have achieved the quality standards set by the vehicle assemblers (known as Q1 at Ford and Spear 1 at G.M.) than their U.S. counterparts have. Several of the strongest Canadian-owned firms make-up part of the threshold group of companies discussed in Volume I. These threshold parts firms range in size from $40.0 million to $1.0 billion in sales and in many cases have become dominant in the North American market in one or more product niches. Nevertheless, these firms still face major competitive hurdles, especially in moving toward greater product design responsibilities.

Unfortunately, some parts manufacturers in Canada have not yet accepted the need for continuous quality improvement, cost reduction, and greater initiatives in R & D. In addition, when compared to the U.S. industry, the Canadian parts industry lacks depth. It is made up of a smaller number of manufacturers spread over an almost equivalent range of products.

A major competitive factor for the Canadian parts sector has been its substantial labour cost advantage over the U.S. industry. This is largely due to the exchange rate, which contributes a labour cost advantage of about 30 percent. However, this advantage is slowly being eroded by the recent increase in the value of the Canadian dollar and the costs of inflation-protected pensions for Canadian workers.

The North American automotive parts industry is now undergoing unprecedented changes. Major U.S.-based multinational parts suppliers are developing new business links and joint ventures with overseas producers to gain access to markets and technology. In the next decade, the number of North American original equipment parts producers will likely shrink. These changes stem from the fact that North American vehicle producers are sourcing more and more parts and vehicles from Japan, from low-cost developing countries, and from their overseas affiliates as part of their strategic positioning and cost reduction efforts. As demonstrated in Exhibit V.8, Canadian imports of automotive parts from outside North America increased from 2.6 percent in 1978 to 7.4 percent in 1985.

G.M. and the other vehicle manufacturers are steadily increasing the rate at which they source components and parts from independent suppliers. They are also transferring R & D functions to the major component manufacturers supplying them. There has been a shift to long-term contracts and a small number of parts suppliers which allows close working relationships and which can support the large capital and training investments parts makers are expected to make to fulfil their new responsibilities. Furthermore, the range of automotive suppliers is increasing in response to the demand for new products, equipment, and material technologies, including plastics, computers, and other electronics. Driven by these and other changes, capital spending in the auto parts industry increased substantially in the early 1980s, especially for new machinery and equipment to manufacture light-weight components and parts for front wheel drive vehicles (See Exhibit V.9)

THE INTERNATIONAL AUTOMOTIVE ENVIRONMENT

The U.S. Industry

In the United States, the motor vehicle industry continued its healthy overall performance in 1986 with record sales. The U.S. auto industry sold 16.3 million domestic and imported cars and trucks in 1986, an increase of 3.8 percent over 1985 and 5.8 per-

EXHIBIT V.8

CANADIAN IMPORTS OF AUTOMOTIVE PARTS BY COUNTRY
($ Millions)

	1978	% Of Total	1985	% Of Total
United States	7,336.0	97.4	16,304.1	92.6
Mexico	11.1	2.6	534.2	7.4
Japan	40.4		359.8	
Sweden	45.7		99.7	
Brazil	7.2		32.1	
Taiwan	0.5		18.7	
Hong Kong	0.7		3.4	
Korea	0.1		14.2	
United Kingdom	26.1		41.4	
France	25.8		45.7	
West Germany	24.9		85.1	
All Other Countries	15.2		60.8	
Total Imports	7,533.7	100.0	17,599.1	100.0

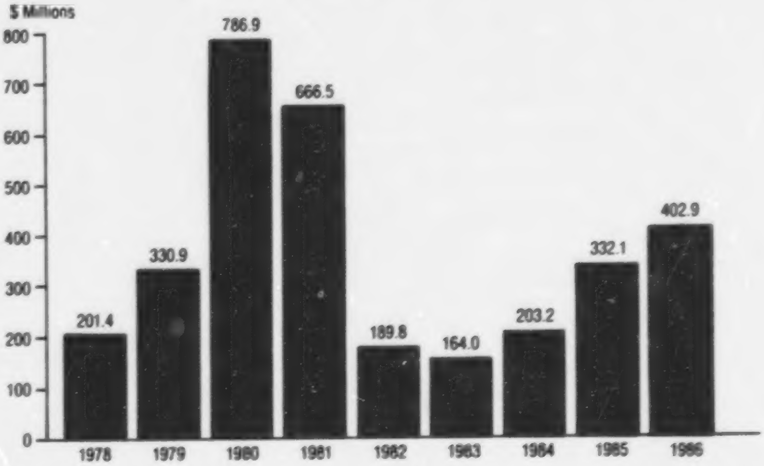
Source: Statistics Canada and Automotive Parts Manufacturers Association

cent higher than the previous sales record, set in 1978. But, despite low-cost financing and company rebates, sales in 1987 dropped to 15.2 million, down 6.9 percent from 1986. The traditional domestic automakers are continuing to lose domestic market share. Sales of domestically manufactured cars and trucks dropped to 11 million units in 1987, down from the 12.1 million units sold in 1985 and 1986. Similarly, sales of imported cars and trucks dropped by 4.8 percent to 4.0 million in 1987, compared to 4.2 million in 1986. However, there are variations within the industry, with Ford enjoying excellent sales levels while G.M. is coming out of a slump.

The U.S. industry produced 10.9 million cars and trucks in 1987. Total U.S. vehicle production dipped slightly by 3.8 percent over 1986 production levels and remained well below the peak of 12.9 million units set in 1978. This decreased production has more than likely resulted in a decrease in capacity utilization. Peak capacity utilization occurred in 1978 at 89 percent. Employment

EXHIBIT V.9

CAPITAL INVESTMENT IN CANADIAN AUTOMOTIVE PARTS INDUSTRY 1978-1986



Source: Statistics Canada

zation. Peak capacity utilization occurred in 1978 at 89 percent. Employment in the U.S. vehicle and equipment industry reached 873,000 in 1985, which was 6,000 higher than the 1984 level, yet well below the 1979 peak of 990,000 workers.

U.S. passenger car sales reached 10.3 million units in 1987, a decrease of ten percent over 1986 sales. Offshore imported autos constituted 31.1 percent of the total passenger car market in 1987, an increase of 2.8 percent from 1986. Non-Japanese brands accounted for 79 percent of this increase. Sales of domestic cars stabilized at about 8.2 million units in 1985 and 1986 and dropped to seven million in 1987, well below the peak of 9.7 million units in 1973. The automotive industry forecasts that U.S. sales of domestically produced Big Three products will decline by six percentage points over the next ten years due to increasing imports and expanded foreign-owned assembly capacity in the U.S.[1].

North American Overcapacity: Contending with Foreign Transplants

Although the market share for imports produced outside North America (excluding Japan) will increase slightly, major market gains are forecast for Japanese cars manufactured in the United States (See Exhibit V.10). Japanese automobile manufacturers are building a considerable amount of vehicle assembly capacity in North America. This investment is largely in response to the rapid appreciation of the yen, the evergrowing protectionist sentiment in the U.S. and the significant opportunity afforded by the large North American market. Other factors stimulating this investment include North America's political stability and, assuming that the U.S. dollar - Japanese yen relationship continues, the perception by the Japanese of the U.S. and Canada in particular as low cost producers. Moreover, the first Japanese transplant facilities such as Honda's Ohio operation have found that Japanese production systems and work force organization can largely be transplanted to North America.

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[1] University of Michigan, *Forecast and Analysis of the U.S. Automotive Industry Through 1995*, Delphi IV, 1987.

By 1990, there will be at least ten Japanese and Korean plants in operation in Canada and the U.S. The total investment is estimated at $5.3 billion dollars with a capacity of 2.1 million units (See Exhibit V.11).

Although North America represents a large market, it is expected to grow slowly in the future. In fact, some analysts predict that sales in the U.S., will drop in 1988 by five percent, reflecting an expected pause in the market after five strong years. However, when demand turns up in 1990 the new transplants will account for about 15 percent of North American production and, since imports are expected to continue at the same rate, the combination of the two will place extreme pressure on Detroit's market share.

Some analysts predict a two to three million unit passenger car overcapacity in North America by 1990. This could result in the closure of as many as ten assembly plants in North America, with an estimated job loss of 150,000 in the auto industry. Indeed, an analysis of the North American assembly capacity indicates that the two to three million unit overcapacity may be conservative and predicts a figure closer to five million units (See Exhibit V.12).

The overcapacity will force a significant rationalization of North American plants. Some of the less competitive assembly facilities will be closed, leading also to the closure of some parts suppliers. Even though much of the older capacity will be phased out much excess capacity will remain. Asian manufacturers are building assembly capacity in North America not only to supply the U.S. and Canadian markets, but also to circumvent European import restrictions. The Big Three, in particular G.M., may keep surplus manufacturing open in the hope of reclaiming some of their lost market share and maintaining it at a reasonable level.

EXHIBIT V.10

U.S. PASSENGER CAR MARKET
Percentage Share

Manufacturer	Estimate	Median Response	
	1985	1990	1995
GM	42.2%	40.5%	38.9%
Ford	18.9	18.0	17.4
Chrysler	11.3	11.0	10.3
AMC/Renault (New Chrysler-owned)	1.2	1.0	0.5
VW of America	2.0	1.5	1.6
Domestic Joint Ventures (e.g., NUMMI, Diamond-Star)	0.3	1.8	2.1
Japanese-Manufactured in U.S. (e.g., Honda, Nissan)	1.6	3.5	5.2
Other Foreign Manufacturers in U.S.	0.0	0.0	0.5
Japanese Imports	18.5	18.0	18.4
Other Imports (Produced outside North America)	4.0	4.7	5.1
TOTAL	100.0	100.0	100.0

Source: University of Michigan, Forecast and Analysis of the U.S. Automotive Industry Through 1995, Delphi IV, 1987

EXHIBIT V.11

JAPANESE AND KOREAN OWNED ASSEMBLY PLANTS IN NORTH AMERICA

Country/Company		Direct Investment (U.S. $ Millions)	Capacity (Units)	Estimated Direct Employment
U.S.A.				
Toyota	Fremont, California	400	250,000	2,500
	Georgetown, Kentucky	800	200,000	2,000
Nissan	Smyrna, Tennessee	745	240,000	2,100
Honda	Marysville, Ohio	490	360,000	3,500
Mitsubishi	Bloomington-Normal, Illinois	500	240,000	1,800
Mazda	Flat Rock, Michigan	450	240,000	2,000
Subaru/Isuzu	Lafayette, Indiana	480	120,000	2,000
Total U.S.A.		3,865	1,650,000	15,900
Canada				
Toyota	Cambridge, Ontario	400	50,000	1,000
Honda	Alliston, Ontario	200	80,000	700
Hyundai	Bromont, Quebec	300	100,000	1,200
GM/Suzuki	Ingersoll, Ontario	500	200,000	2,000
Total Canada		1,400	430,000	4,900

Source: Ward's Automotive Yearbook, 1987.

EXHIBIT V.12

ANALYSIS OF NORTH AMERICAN ASSEMBLY CAPACITY

Total Asian North American (N.A.) Production[1]	2,080,000
Add imports (25.4% of market '86)[1]	4,200,000
Total vehicles controlled by foreign producers	6,280,000
Add new N.A. production (G.M. Saturn)	500,000
Total new N.A. entrant by 1989	6,780,000
Add existing N.A. production capacity[2]	13,177,000
Total N.A. supply capability	19,957,000
Less projected sales 1989-90[3]	14,700,000
Production overcapacity	5,257,000

Source: 1. Ward's Automotive Yearbook 1987
2. 1986 Production = 13,177,000 units at 86% capacity.
3. Projected Sales: Represents average estimates of Bursey International, Arthur Anderson Delphi V, 1987 and University of Michigan Delphi IV, 1987.

As overcapacity continues, it will put pressure on prices which could favour the Japanese who also seem to be willing to accept narrow margins to build or maintain market share. Currently, overcapacity is having an affect on the operations of the transplants. Volkswagon, for example, has announced its intention to close its plant in Westmorland, Pennsylvania. NUMMI (a G.M./Toyota joint venture) in the last 18 months has cut production of the Toyota Corolla and Chevy Nova by 30 percent. While Honda appears to be prospering during this difficult period, other Japanese manufacturers have suffered as sales have fallen.

Regardless of its extent, overcapacity in North American vehicle manufacturing will have an impact on Canadian auto parts exports to the United States. With about 80 percent of Canadian production exported to the United States under the Auto Pact, the Canadian parts industry's fortunes are closely linked to conditions in the U.S. market. Foreign vehicle assemblers operating in North America will not generate North American value-added levels comparable to those reached by North American assemblers because the foreign assemblers are expected to source components from their home bases, at least initially. Only an upward revaluation of the yen against the North American currencies would accelerate the growth of North American value-added in foreign assembly operations.

The Western European Auto Industry

After more than two years of economic stagnation, the economic picture for Western Europe brightened in 1986. The major European motor vehicle manufacturers increased production from 10.5 million units in 1985 to approximately 11.3 million in 1986.

Western Europe enjoyed a record year for new car sales in 1986. Sales were up 9.4 percent, amounting to 11.6 million units, compared to 10.6 million units in 1985. Almost half the increase (450,000 units) was due to an 8.9 percent increase in new car deliveries in West Germany. Car sales rose by 8.2 percent in France between 1986 and 1985, by 4.5 percent in Italy, and by 2.7 percent in the United Kingdom.

The European market was subject to economic pressures that could easily have decreased sales, but the prevailing overcapacity resulted in price competition that boosted total volume. Overcapacity remains a problem, but no plants have been closed as yet. Most European automakers have been successful in reducing costs, and many made profits in 1985. Renault and SEAT[1] were the unprofitable exceptions. Higher profit margins were earned by specialty car companies because of their greater pricing power. Continued improvement at Ford and G.M. in Europe in net income, sales, and operating efficiencies contributed to strong improvement in the earnings of those companies.

Nevertheless, Japanese vehicles continued to occupy the top spot in eight Western European markets. Collectively, Japanese firms accounted for 11.7 percent of Western Europe's passenger car sales in 1986. This was up from 10.7 percent in 1985. Sales of Japanese vehicles are strongest in countries that lack production. All European markets, however, have some restrictions on Japanese imports. With little appreciation of the yen versus major European currencies, Japanese exports to Europe during 1986 were 12.8 percent higher than in 1985. MITI, the Japanese industry ministry, has asked Japanese manufacturers to limit exports to a ten percent increase in market share for EEC member states. Any long-term restrictions on Japanese exports will likely result in the Japanese engaging in local production.

The Japanese Automotive Industry

Exports of Japanese vehicles to Canada, the United States, and the European Community increased in 1986, while they decreased in all other markets (See Exhibit V.13). Consequently, the Japa-

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[1] Sociedad Espanola De Automoviles De Turismo S.A., Madrid Spain; Volkswagen owns 75% of the company with an option to purchase the remaining 25%.

EXHIBIT V.13

DISTRIBUTION OF JAPANESE EXPORTS

Country	1985 Units	1985 %	1986 Units	1986 %
Canada & United States	3,384,563	50.3	3,719,035	56.3
European Community	1,363,694	20.3	1,563,531	23.7
Middle East	401,598	6.0	188,076	2.8
South East Asia	710,587	10.6	456,258	6.9
Latin America	290,417	4.3	268,818	4.1
Africa	137,729	2.0	126,409	1.9
Other	441,884	6.5	282,796	4.3
Totals	6,730,472	100.0	6,604,923	100.0

Source: Ward's Automotive Yearbook, 1987.

nese industry suffered a 1.9 percent decrease in total exports. Strong competition from newly developing countries, the upward valuation of the yen, and protectionist sentiment in North America were major factors leading to this decrease and to the subsequent flattening of production.

In response to these trends, the Japanese automobile manufacturers have been pursuing a strategy of overseas investment and development of new plants to service overseas markets. Eight Japanese firms have established or are in the process of establishing auto assembly plants in North America, either on their own or in cooperation with one of the Big Three. By 1990 Japanese firms are expected to have a total manufacturing capacity of two million units in North America and to be producing 1.3 million units annually.

Historically, the Japanese have considered the United States a prime source of new technologies. However, since the 1970s the focus has switched to Europe. Japanese parts companies are establishing a technology bridge with European manufacturers, and North America is viewed increasingly as a market rather than a source of new technology. If the technology bridge develops without North American participation, then North American parts manufacturers could be relegated to producing low-technology, low-margin parts.

Newly Industrialized Countries

The most dramatic trends in vehicle production are occurring in the newly industrialized countries. Automotive production capacity has been increasing at a rapid rate in countries like South Korea, Mexico, and Brazil. These nations have increased their world production share by one-quarter, from 4.2 percent in 1984 to 5.3 percent in 1986.

One of the more dramatic examples of growth in this portion of the world automotive industry is South Korea. Since 1974 the South Korean government has actively pursued a strategy of developing an export-oriented automobile industry. Joint ventures with foreign partners were vital to the development of the industry. South Korean industry needed capital and technology. In cooperation with the Japanese firm Mitsubishi, Hyundai has spent $500 million on product development and is currently working on a front wheel drive car to meet U.S. safety and emission standards. Daewoo has entered into a 50/50 joint venture with G.M. to sell its product in the United States. Ford is affiliated with KIA, and Chrysler is seeking a link with Samsung, a large conglomerate not currently producing motor vehicles.

The South Korean government reacted to the recession of the early 1980s by rationalizing and reorganizing the auto industry. The government objective was to prevent overcapacity and price wars. It restricted passenger car production to Hyundai and Daewoo and limited KIA to producing trucks and buses. It further designated the motor vehicle industry as a strategic export industry and prohibited any imports of autos. Currently, Hyundai controls 75 percent of the small domestic market for passenger cars and Daewoo the remainder. KIA, Asia, Dong-a, and Keohwa are limited to buses and trucks.

Since 1983 South Korean vehicle production has jumped phenomenally in response to export market demand. Hyundai made a head start in 1983, with exports to Canada and sales of about 5,000 Pony sub-compacts. By 1985, sales had soared to 79,000 units. The company accounted for more than half the increase in import sales in Canada between 1984 and 1985 and continued to maintain its first-rank import position in 1986. However, in 1986 its share of the Canadian passenger car market suffered a slight decrease (from seven percent to 6.4 percent), a trend that continued into 1987 with sales of only 50,646 units, down 27.7 percent from 1986.

Hyundai entered the market quickly but has not been able to match its previous performance. A highly organized dealer network enabled it to establish a foothold quickly in the Canadian market. In addition to positive consumer perceptions of its products, Hyundai's duty-free access gave it a competitive price advantage. Moreover, the voluntary import restraint program for Japanese autos shifted the Japanese strategy to selling higher-priced cars in Canada, creating a market opportunity for Hyundai's low-cost sub-compacts. Recently G.M. and Ford lodged a dumping complaint against Hyundai, and Revenue Canada agreed to levy an import tax on vehicles manufactured by the company. This will no doubt have a negative effect on Hyundai's ability to maintain its share of the market.

In 1987, Daewoo Motors (a G.M. affiliate) began exporting Opel-designed sub-compacts to the United States. It was expected that the import volume would be 85,000 to 100,000 units by 1988, or 50 percent of Daewoo's production capacity for this model. KIA plans to enter the U.S. market in the late 1980s by supplying a mini-car to Ford. Exports are expected to reach 100,000 units by the end of the 1980s. During the next five to ten years, South Korea will become a significant competitor in the world automotive industry. Current production capacity is 700,000 units, and it is predicted that by 1991 this will increase to 2.1 million units. The country's low hourly wage costs and newly trained labour force will attract capital and an infusion of technology. However, there are also factors limiting South Korea's ability to increase its market dominance, including its small domestic market, low per capita income, high taxation of cars and gasoline, lack of an adequate base of suppliers, the very competitive international market and, interestingly enough, looming labour cost increases.

Taiwan, Mexico, and Brazil are the other developing countries with active and growing auto industries. The Taiwan auto industry is in its infancy but is developing rapidly with significant export potential. Ford Motors' affiliate, Ford Lio Ho, is planning significant new capacity and is exporting a small volume of subcompacts to Canada for sale through Mercury dealers. Mexico's auto industry is growing at a phenomenal rate, as are its exports, which until recently were limited to high-value components such as engines and transmissions.

At present the Big Three, along with Volkswagen and Nissan, are active in the assembly of cars and trucks in these emerging producer countries. Brazil's 1986 production of vehicles was 9.3 percent higher than in 1985. Volkswagen was the leading producer, with 387,735 units or 35.4 percent of all Brazilian production. General Motors vehicle output was about 250,000 (23.8 percent of total output), while Ford produced about 190,000 units representing 18 percent of vehicle production. Production in Mexico and Brazil by these manufacturers constitutes a major strategic response to competition from Korea and Japan in the North American small car market segment.

AUTOMOTIVE INDUSTRY OUTLOOK

During the next decade the Canadian automotive industry will undergo a significant amount of restructuring and will face increasing foreign competition both at home and abroad. After three consecutive years of sustained recovery, the Canadian market for passenger cars is expected to stabilize. Based on market projections, considerable overcapacity is expected to exist in passenger car production in North America by 1990. This surplus capacity may reach five million units. While most of the overcapacity will be in small car manufacturing, some is also expected in the mid-size segment. The bulk of Canadian production is devoted to mid-size automobiles, which will also be under increasing pressure from Japanese competition as they attempt to gain a greater portion of the higher value part of the market. Clearly, any reduction in vehicle production in Canada will have a severe impact on the parts sector, as will increased offshore parts sourcing by the North American vehicle assemblers.

Market growth in the major automotive producing countries is predicted to be slower, compounding the adjustment difficulties for major world producers. The North American automobile market is expected to experience very modest growth of only one or two percent per year for the rest of the decade. Import penetration levels will increase to 25 or 35 percent, with newly industrialized countries increasing their exports to North America, mainly in the form of captive imports by the Big Three and Volkswagen. With the offshore producers developing new assembly capacity in North America, these transplanted manufacturers will be bidding keenly for a share of the slow-growing North American market.

CHAPTER VI
THE CHEMICALS INDUSTRY

The development of major new chemicals has slowed in recent years, and much of the industry is now in a mature stage of growth. The years between 1940 and 1960 saw the most active period of chemical substitution for traditional products. Chemical production increased at approximately twice the rate of growth in the gross national product between 1950 and 1974 as those new products took hold in the marketplace and entered everyday use. Yet even as chemical production was booming, the pace of innovation was slowing. Between 1930 and 1980, there were 60 major innovations in chemical products and processes; however, 39 of these were introduced before 1950, 18 between 1950 and 1970, and only three between 1970 and 1980. The chemical industry today still has high growth segments, but the largest part of the industry is now made up of mature manufacturing businesses.

The competitive dynamics of the chemical industry can best be understood by dividing it into two general types of businesses—high-volume commodities and low-volume specialty products. The commodity businesses are primarily cost-driven and are characterized by low profit margins and relatively low investments in research and development. This segment of the industry is usually subdivided into organic and inorganic chemicals. Organic chemicals (petrochemicals) are manufactured from either crude oil or natural gas based feedstocks. Primary petrochemicals include olefins (ethylene, propylene, and butadiene), aromatics (benzene, toluene, and xylene), methanol, and ammonia. These primary petrochemicals are upgraded to intermediates, such as styrene and ethylene dichloride, which in turn are the feedstock for a wider range of products, such as synthetic rubbers, large volume plastic resins like polyethylene, and polyvinyl chloride.

Inorganic chemicals are not based on petrochemical feedstocks, but are either expressly manufactured from non-petroleum based raw materials or are the byproducts of a non-petroleum based manufacturing process. Examples are such products as sulphuric acid and caustic-soda. While many analyses of the industry distinguish between these two segments, a business analysis does not for two reasons. Firstly, the inorganic nature of some chemical businesses does not determine their competitive dynamics. A commodity inorganic business may have much more in common competitively with a commodity organic business than with more specialized inorganic businesses. Secondly, the Standard Industrial Classification (SIC) does not distinguish between inorganic and organic, creating limitations in the data available for analysis. Only in trade data is the distinction made and then on a product specific basis.

In general, specialty chemicals businesses are driven by very different competitive factors than commodity businesses. Many of the specialty businesses are applications-driven and most are characterized by relatively high profit margins as well as higher research and product development costs. Products in this category include plywood adhesives, paints, solvents, inks, and synthetic textiles.

GLOBAL RESTRUCTURING

Since the early 1970's, the international petrochemical industry has undergone a major restructuring. Chemical companies in industrialized countries have been rationalizing their commodity chemical capacity and refocusing their efforts on specialty products. This restructuring was forced by rising fuel prices in the post-1979 period which pushed up the costs of all petrochemical products in an environment where demand for commodity chemicals was stagnating. Profits disappeared for many firms during the ensuing cost-price squeeze. The resulting overcapacity was exacerbated by the opening of major new plants in petroleum-rich areas like Canada, the Middle East, and Latin America. These investments were made in anticipation of a growth in demand for commodity chemicals that never materialized. Overall profitability plunged by 37 percent among the 12 largest U.S. firms between 1982 and 1983, and major Japanese and European firms recorded significant operating losses. Industry's response to the overcapacity was to close its older and less efficient facilities in favour of the newer capacity coming on stream.

Encouraged by the promise of high growth rates and improved profitability, companies expanded into specialty chemical areas. Estimates for future market growth for all specialty chemicals are in the six percent per year range—much higher than commodity chemicals—and in some cases are as high as 20 percent per year (See Exhibit VI.1). Profitability has also been much greater in specialty chemicals than in high-volume commodity chemical products (See Exhibit VI.2).

The result of these shifts has been a dramatic restructuring of all major chemical firms and a diversification by some into the specialty segment. Enichen and Montedison in Italy have shut down half their bulk chemical capacity since 1981, laying off tens of thousands of workers. All told, about one-quarter of the devel-

EXHIBIT VI.1

GROWTH RATES OF MAJOR U.S. SPECIALTY CHEMICAL MARKETS*

(Canadian $ Millions)

Segment	Size of U.S. Market	Estimated Annual % Growth Rate 1985-91
Agricultural Chemicals**	$7,700	3%
Oil Field Chemicals	5,700	4
Industrial Coatings	5,600	3
Electronic Chemicals	5,200	14
Industrial Cleaners	4,100	3
Specialty Polymers	2,800	9
Diagnostic Chemicals	2,400	10
Plastic Additives	2,300	5
Catalysts	2,100	4
Water Treatment Chemicals	2,100	3
Petroleum Additives	2,100	3
Adhesives & Sealents	1,900	8
Advanced Polymers and Composites	1,800	20
Remainder	13,600	N/A
Total	$59,400	6%

* Excludes pharmarceuticals

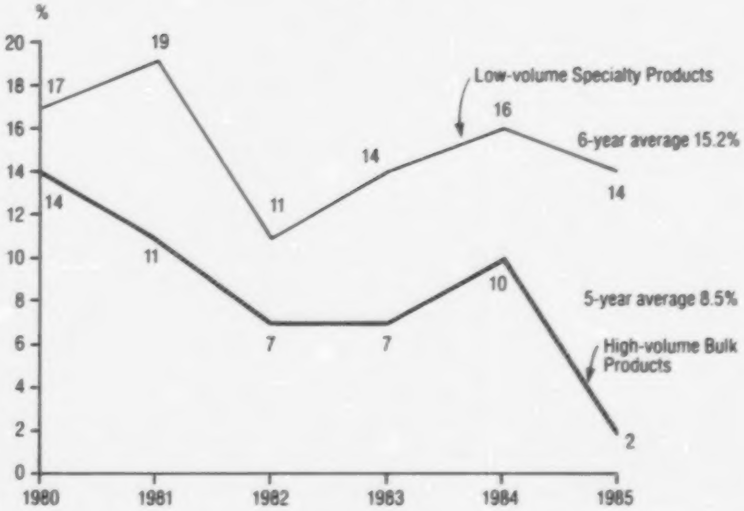
** Does not include fertilizers

Source: Strategic Analysis, Reading, PA

oped world's commodity chemical capacity has been retired or mothballed in the last six years. Since 1981, Dow Chemical has sold $1.8 billion worth of chemical businesses, most of them commodity producers, left joint petrochemical ventures in Japan, Saudi Arabia, South Korea, and Yugoslavia, shed 10,000 workers, and spent $1.3 billion acquiring specialty chemical businesses. Monsanto increased the proportion of its assets in specialty chem-

EXHIBIT VI.2

U.S. CHEMICAL MANUFACTURING
RETURN ON SHAREHOLDER EQUITY
1980-85



Source: Kline & Co., Annual Reports

icals from 74 percent in 1981 to 97 percent in 1987. ICI of Britain increased specialty chemicals from 30 percent of sales in 1981 to 50 percent in 1986. Meanwhile, U.S. chemical firms have increased their spending on R & D from 2.5 percent of sales in 1979 to 4.4 percent in 1986 in efforts to develop new specialty chemicals and applications.

By 1986, the restructuring began to pay off. The demand for commodity chemicals picked up, and capacity utilization had increased from 66 percent in 1982 to more than 80 percent by 1986, dramatically improving profitability. Cost reduction programs instituted in the early to mid-1980s have had a major impact on the operating profit margins of chemical companies, in some cases doubling their 1982 levels. Overall profitability of the major U.S. chemical firms rose from a nine percent return on equity in 1983 to 13 percent in 1986. Although the restructuring is not complete, many chemical firms are over the worst, and fast-rising investments in R & D signal a continued move toward specialty products.

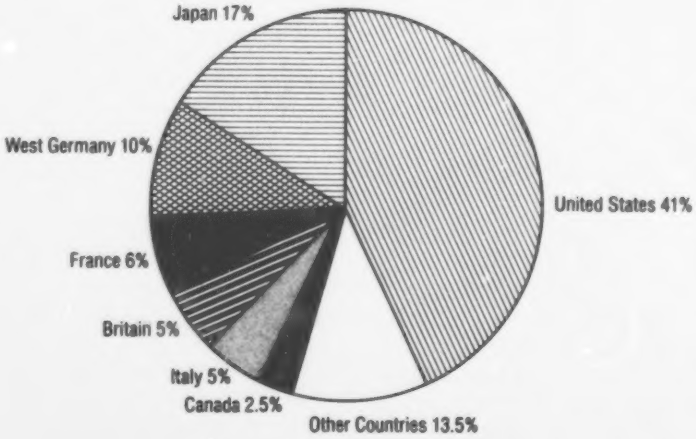
Shifting an increasing share of production to specialty chemicals businesses is not easy. The competitive demands of specialty chemicals businesses generally require different capabilities and skills from most commodities businesses. Gaining a competitive advantage in specialty chemicals means developing or acquiring proprietary product processes, special formulation skills, applications engineering to tailor a product to individual customer needs, and marketing coverage of specialty markets. In commodity chemicals, competition is based primarily on raw material costs, plant scale and efficiency, and transportation costs. Restructuring therefore has meant changes not only in production facilities but also in management approaches, resource allocation, and work force skills.

CANADA'S TRADE POSITION

Canada is a relatively small player in the $675 billion world chemical industry. Canada accounted for only 2.5 percent of world chemical industry sales in 1986, compared to 41 percent for the United States and 17 percent for Japan (See Exhibit VI.3).

EXHIBIT VI.3

WORLD CHEMICAL INDUSTRY SALES
1986
(C$675 billion)



Source: Chemical and Engineering News; U.S. Dept. of Commerce; Statistics Canada.

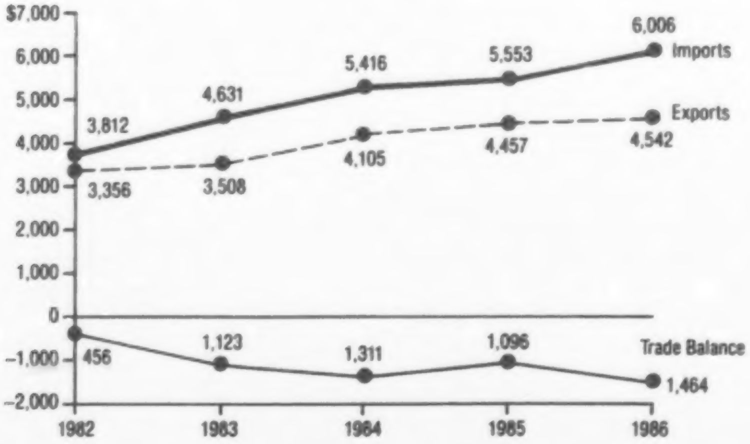
High-volume commodities account for 88 percent of Canadian chemical industry production and 80 percent of exports, while specialty chemicals account for only 12 percent and 20 percent respectively.

One-quarter of Canadian chemical production is exported, and two-thirds of that goes to the United States. However, Canada's chemical trade deficit more than tripled between 1982 and 1986 (See Exhibit VI.4). This was mainly because of rapid growth in imports, as exports have remained fairly constant as a proportion of factory shipments. Together, the United States and the European Economic Community (EEC) account for more than 80 percent of Canada's chemical trade.

Ontario is responsible for more than half (59 percent) of Canada's chemical production. However, Ontario chemical companies have not been quick to respond to changing market conditions and opportunities. The Ontario industry therefore remains uncompetitive in large parts of the market, especially the research and development-intensive specialty chemicals. As a result, Ontario's trade position in chemicals seriously lags behind

EXHIBIT VI.4

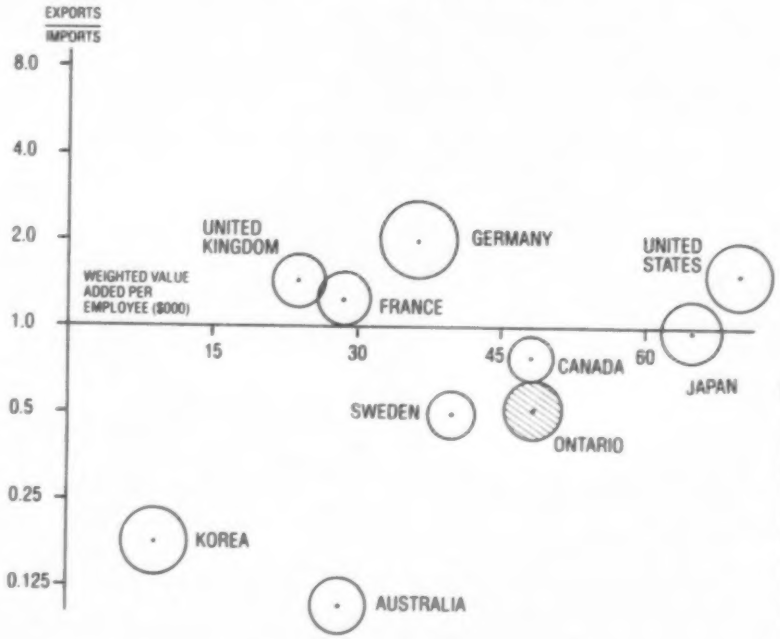
CANADIAN CHEMICAL INDUSTRY
Import and Exports
1982-86
($ Millions)



Source: Statistics Canada, Department of Regional Industrial Expansion.

EXHIBIT VI.5

CHEMICALS
STRENGTH OF MANUFACTURING STRUCTURE
1983
(At 1986 Exchange Rates)



Circle size is proportional to % of total employment in chemicals relative to all manufacturing.
Source: Telesis and Canada Consulting analysis based on individual country statistics and U.N. Trade Statistics Yearbook

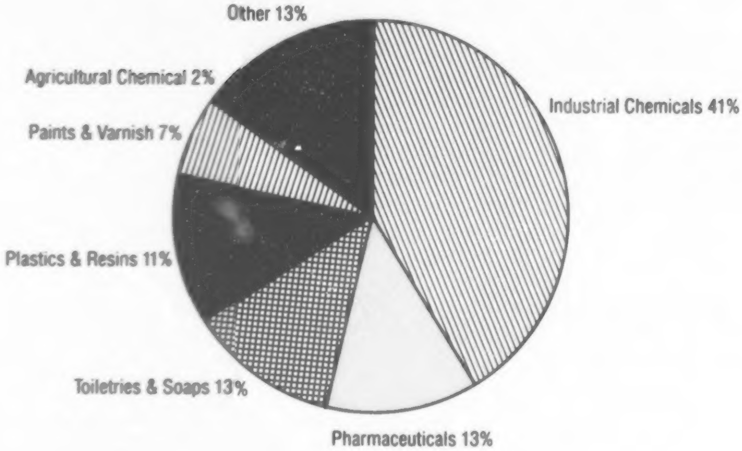
that of the United States, Japan, the United Kingdom, West Germany, and France (See Exhibit VI.5).

COMPETITIVE DYNAMICS

The chemical industry can be divided into seven segments, each of which contains some specialty and some commodity businesses (See Exhibit VI.6). Within each of these broad industry segments there are specific businesses, each with its own competitive dynamics (See Exhibit VI.7). Industrial chemicals, plastics, and resins dominate Canada's chemical exports, but only in industrial chemicals does Canada have a strong competitive position, as shown by the generally positive trade balance and higher

EXHIBIT VI.6

CANADIAN CHEMICAL PRODUCTION - 1986
$18.2 Billion



Source: Statistics Canada/Department of Regional Industrial Expansion

level of value-added per employee (See Exhibit VI.8). However, these competitive advantages will not continue to yield trade and economic benefits indefinitely because the market for commodity chemicals is unlikely to grow significantly in the future and Ontario is not as well positioned as Western Canada and certain other producers in these segments.

Canada's competitive strengths lie mainly in its lower energy costs and wage rates relative to the United States. The average Canadian wage rate is $15.36 an hour, compared with $21.99 in the United States. Energy and petrochemical feedstock costs in western Canada are lower than in the United States, while those in eastern Canada are comparable. These strengths are reflected in the high proportion of basic industrial chemicals, plastics, and resins in Canada's production and export figures.

However, Canada's chemical industry is also at a disadvantage relative to the U.S. industry with respect to factors such as capital costs, plant scale, transportation costs, and the level of proprietary products. Capital costs are 10 to 15 percent higher in Canada because of higher interest rates, more expensive construction requirements (because of climate), and other factors. In addition,

EXHIBIT VI.7

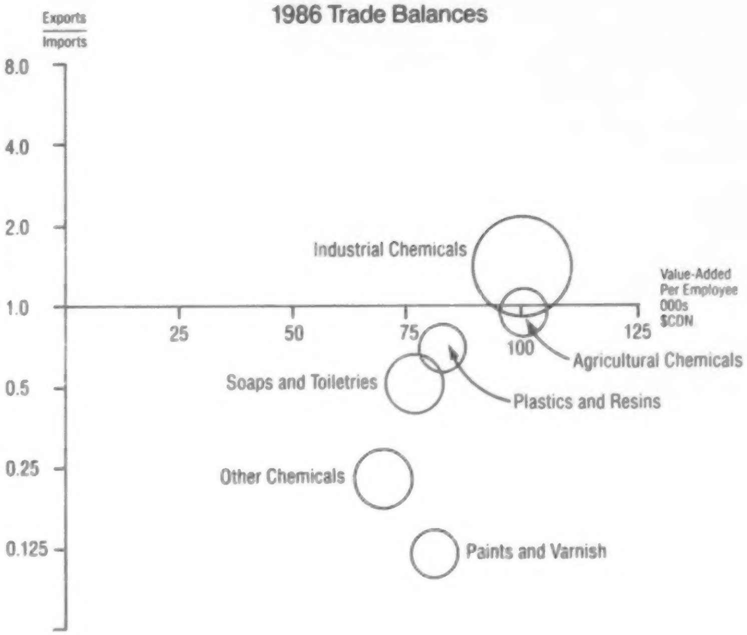
THE SEVEN MAJOR CHEMICAL PRODUCT AREAS

Industry Segment	Types of Products	Growth Rates	Selected Producers	Canadian Ownership
Industrial Chemicals	Ethylene Styrene Surfactants	Low	Dow Chemical Polysar CIL	Low (Except Polysar)
Pharmaceuticals	Vaccines Antibiotics Cancer Drugs	High	Connaught Labs Eli Lilly Syntex	Low
Toiletries and Soaps	Industrial Cleaners Personal Car Products	Medium	Diversey Procter & Gamble Lever Brothers	Low
Plastics and Resins	Polyester Polyvinyl Chloride (PVC) Polyethylene	Medium-High	Dow Chemical Dupont Novacor	Low (Except Novacor)
Paints and Varnish	Automotive Paint House Paint	Medium-High	CIL PPG Canada	Low
Agricultural Chemicals	Nitrogen Fertilizers Pesticides Herbicides	Low	CIL Cyanamid	Low
Other Chemicals	Printing Inks Adhesives	Medium-High	Reichold Basf Inmart	Medium

Source: Canada Consulting and Telesis analysis based on industry interviews and published data

EXHIBIT VI.8

CANADIAN CHEMICAL INDUSTRY COMPETITIVENESS BY SEGMENT
1984 Value-Added Data
1986 Trade Balances



Note: Circle size is proportional to percentage of total industry employment.
Source: Telesis and Canada Consulting analysis based on data from Statistics Canada.

Canadian producers are generally at a disadvantage relative to most large U.S. markets because of greater distances and higher transportation costs. With respect to plant scale, Canada's major industrial chemicals, plastics, resins, and nitrogen plants are, on the whole, comparable in scale to U.S. facilities, but many of Canada's plants producing specialty products like plywood adhesives and solvents are sub-scale. Finally, high levels of foreign ownership in the chemical industry and low levels of R & D have left Canada with few strong competitive positions based on proprietary products.

RESTRUCTURING OF THE CANADIAN INDUSTRY

Like its counterparts elsewhere, the Canadian chemical industry has undergone a significant restructuring. Canadian petrochemical companies have reduced their work forces by about 12 percent since 1981. One major Ontario chemical producer has cut its work force by 25 percent in that time, thereby achieving a productivity gain of six to seven percent annually. Other chemical companies indicated significant reductions in overhead and fixed costs. Novacor of Alberta mothballed two of its three methanol plants and purchased Union Carbide's Ontario polyethylene plant in efforts to rationalize its polyethylene production and gain direct access to eastern markets.

Ontario-based Polysar assumed the total ownership of Petrosar, its major supplier, to increase operating efficiencies and ensure feedstock supply. Both Polysar and Petromont of Quebec are investing heavily to move away from reliance on the more expensive oil-based feedstocks and towards the use of natural gas liquids in order to obtain feedstock flexibility. This allows companies to take advantage of variations in the cost of raw materials.

However, restructuring of the Canadian chemical industry has not resulted, as it has elsewhere in the world, in a shift towards higher expenditures on research and development and more production of specialty chemicals, the market segment where growth and returns are generally higher. Instead, the emphasis has been on achieving better rates of capacity utilization in producing the commodities where Canada's competitive strengths have traditionally resided.

Expenditures on R & D and applications engineering—the activities on which competitive success is usually built in specialty chemicals businesses—have not increased in Canada, resulting in little movement away from commodity chemicals and towards specialty products. By comparison, U.S. expenditures on chemical R & D were increasing by 12.5 percent per year between 1976 and 1985 (5.6 percent in constant dollars) and had reached 4.5 percent of sales by 1986. The top U.S. chemical companies are spending a large share of their profits on R & D (See Exhibit VI.9). In contrast, Canadian chemical R & D spending in 1985 was below 1977 levels for both Canadian-owned and foreign-owned firms.

One Ontario company interviewed was an exception to this general trend, demonstrating that enhanced R & D can pay off even in commodity products. The company had not been spending anything on R & D for a particular commodity, but it had launched a $1.8 million program in 1984-1986 to improve the product and its manufacturing process.

In conjunction with the R & D expenditures, capital expenditures, which had been minimal, were increased to $17.1 million, virtually none of which was spent on increased capacity. The result was a 43 percent reduction in the product's variable cost

EXHIBIT VI.9

CHEMICAL RESEARCH AND DEVELOPMENT EXPENDITURES IN CANADA

R&D As Percentage Of Sales
By Ownership

	1973	1977	1980	1985
Canadian-Owned	1.9%	1.7%	1.3%	1.4%
Foreign-Owned	1.7	2.1	2.1	1.8

Source: Canadian Chemical Producers Association

U.S. CHEMICAL PRODUCERS RESEARCH AND DEVELOPMENT EXPENDITURES

Company	R&D Expenditures U.S. $ Millions 1986	Percentage Change 1985–86	R&D As Percentage of Sales
Dow Chemical	$605	10.6%	5.4%
Monsanto	523	11.3	7.6
American Cyanamid	278	11.1	7.3
Union Carbide	148	(18.2)	2.3
Rohm and Hass	133	7.7	6.4
Hercules	71	(6.6)	2.7
Air Products and Chemicals	61	19.5	3.1
Olin	56	5.0	3.3
Ethyl Corporation	47	1.0	3.0
Pennwalt	45	14.2	4.1

Source: Chemical Week

and a doubling of earnings before interest and taxes, despite higher depreciation expenses. The company was initially concerned that the large expenditures might prove unjustified, but the rapid return on investment has opened the way for similar programs in other products.

INDUSTRY ISSUES

The Canadian chemical industry has identified three issues as important to its future: feedstock costs, transportation deregulation, and government subsidies.

The high cost of transportation in Canada's regulated environment is perceived by producers to place them at a disadvantage relative to U.S. chemical producers. The freedom to move products through the most cost-effective transportation system was cited as a key industry issue. The bulk nature of many chemical products means that a cost-effective and competitive transportation system is essential to international competitiveness. Many companies also believe that transportation costs are higher because environmental concerns in Canada have been translated into more stringent requirements on transporters than are present in the U.S.

Feedstock prices were unanimously cited by companies as the most critical issue for the industry. Feedstock is the largest single cost component in many of the key industry segments, and energy-based feedstocks are used in much of the industry. Producers are adamant that the price of feedstocks in Ontario must be internationally competitive, particularly because of the low profit margins associated with many of the bulk commodity products. Ontario producers argue that the federal government should refuse to implement any policy that alters the free-market structure of feedstocks.

Several chemical companies pointed to government subsidies as another major issue. Authorized assistance by the Department of Regional Industrial Expansion to the chemical industry between 1975 and 1987 amounted to $227.4 million, 70 percent of which went to aid restructuring of the Quebec chemical industry. These federal subsidies to Quebec plants were seen as unfair competition, but perhaps more important, they are seen by many Ontario producers as merely delaying much-needed rationalization of the industry's production capacity. Most of the large Ontario chemical producers would prefer to see government stay out of plant financing. However, smaller producers had mixed views on this subject, particularly as a trade agreement with the U.S. would likely hit them harder than the larger producers.

Notwithstanding the importance of issues such as transportation and feedstock costs to the future of Canada's chemical industry, the key challenge for the Ontario industry is to move into the higher-value specialty product segments of the chemical market. The demand for commodity chemicals is rebounding after a number of years of slow growth, but any new Canadian capacity will likely be built in the west because of its advantage in raw mate-

EXHIBIT VI.10

THE EFFECTS OF CANADA-U.S. FREE TRADE BY CHEMICAL BUSINESS SEGMENT

Selected Industry Segments	Canadian Tariff Rates %	U.S. Tariff Rates %	Likely Effect of Free Trade On Canadian Industry
Commodity Products			
Ethylene	0	0	No effect
Methanol	10	18	Increased exports
Synthetic Resins	9.6–10.1	9.4–12.8	Mixed/on balance neutral
Styrene	7.5	7.4	Neutral
Specialty Products			
Crop Protection Chemicals	0	6.8–13.5	No effect—Canada lacks industry to export
Printing Inks	13.1	1.8	Canadian producers would suffer
Detergents	12.8–19.4	1.3–7.7	Some rationalization back to U.S. facilities except where environmental regulation differences are significant or Canadian facilities are at U.S. scale
Plastic Pipe	13.5	3.1	Canadian producers have cost disadvantage; import surge likely

Source: Canada Consulting and Telesis analysis based on Customs and Excise and Regional Industrial Expansion data and interviews.

rial costs. Specialty chemicals are a rapidly growing market segment and represent an opportunity for the Province of Ontario. However, any move in this direction faces two important hurdles. The industry currently carries out little R & D, and the specialty chemical producers that do exist are not competitive with U.S. firms. Many of the specialty firms are smaller and do not have large resources to carry out R & D activities. Risk sharing incentives targeted at encouraging new product development might enable both established commodity firms and specialty producers to move more quickly towards new specialty products.

Canada's commodity chemical producers could fare well under a free trade regime, but specialty segments could be hurt if they have cost disadvantages or lack the scale necessary to compete with U.S. producers (See Exhibit VI.10). Ontario will therefore need to consider restructuring assistance to some specialty firms in response to any changes in the trade relationship with the U.S.

THE STATE OF HIGH GROWTH AND EMERGING INDUSTRIES

CHAPTER VII

TELECOMMUNICATIONS EQUIPMENT

The telecommunications equipment industry has been one of Canada's most successful in recent years. A large and R & D-intensive indigenous multinational corporation, Northern Telecom, together with a number of smaller but strong competitors, make the Canadian industry vital and dynamic. Vitality is one aspect of competitiveness in the world telecommunications industry, but appropriate corporate strategies and skillful management of technology are also required to maintain a strong market position, a sustainable competitive advantage, and the profits that go with them.

The nature of the telecommunications industry and the pace of technological change within it are constantly increasing the cost of entry. One barrier to entry in telecom markets is the sustainable position created by an established company's base of installed equipment. Unless the new competitor's products are much superior to those of the company with which a customer already deals, the customer is likely to continue doing business with its current supplier. In these circumstances, the best opportunities for stealing market share lie in technological breakthroughs, such as the introduction of digital equipment by Northern Telecom and others in the late 1970s. The second factor that can sustain a leading position in this industry is the evolution of technology. With each new generation of product or business, the complexity of the research and the costs involved increase. Leading companies can sustain their positions by riding a maturing technology down the complexity curve to the point where profits are sufficient to finance the next generation of research in emerging business segments.

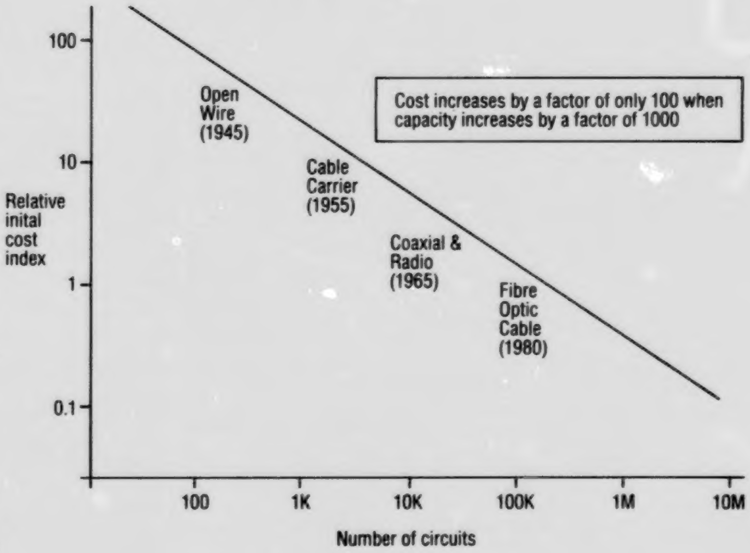
The pace and scale of change make telecommunications equipment an interesting industry to study and one that provides insights into all businesses where rapid technological advances drive growth and competition.

IMPACT OF RAPID TECHNOLOGICAL PROGRESS

Technological progress is the principal driver of growth in the telecommunications industry. The pace and scale of this change

EXHIBIT VII.1

TELECOMMUNICATIONS TRANSMISSION COSTS



Cost increases by a factor of only 100 when capacity increases by a factor of 1000

Source: John Elliot, Fellow Emeritus, Bell Northern Research, 1986.

have stimulated rapidly increasing demand for new equipment, making telecommunications one of the world's fastest growing and most important high-tech industries. Technological improvements have meant that telecommunications transmission costs have typically been reduced by 90 percent every 20 years since 1940. These costs are projected to continue declining at the same rate beyond the year 2000 (See Exhibit VII.1). The impact of improvements in transmission technology has been compounded by strides made in electronics, particularly developments in computer chips.

The effects of these technological improvements are apparent to anyone who has worked in an office setting over the past ten years and are particularly obvious to anyone involved in the purchase of telecommunications equipment during that time. While the cost of systems has been declining by 90 percent every five to 20 years, their functionality has typically improved tenfold every five years. This means that over a five-to-ten-year period, telecommunications equipment has improved approximately 100 times in terms of its functionality per unit of price. These trends are also expected to continue over the next two decades.

The impact of technological progress has not been limited to the growth of the telecommunications industry. Technological change has also had major implications for the competitive dynamics of the industry. It can transform the nature and cost structure of entire business segments in a period of less than five years. It can dictate appropriate strategies and can eliminate from the marketplace even large companies if they adopt inappropriate strategies.

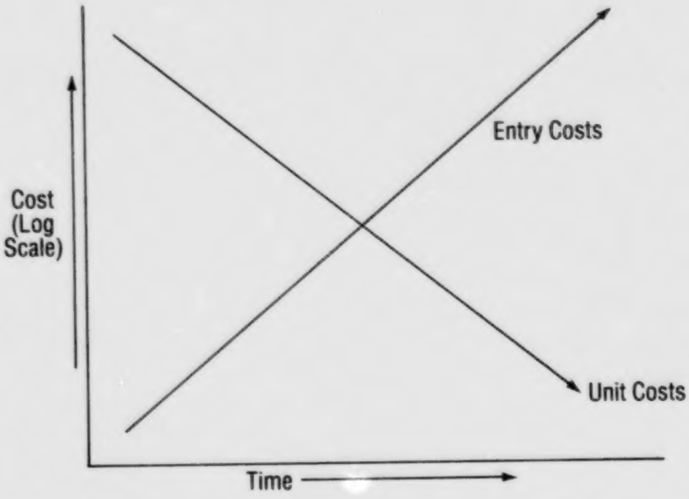
Telecommunications is one of the most dynamic industries in the world today. Competition is fierce, but the opportunities for growth and the potential for exports, especially those with high value-added per employee, are strong.

Given the pace of technological change, the intense competition, and the risky nature of this industry, one might wonder why new entrants each year take large losses in the hope that they can gain enough market share to be competitive in the longer term. Some of the answer lies in the profit potential of this high growth industry, but a large part of the answer is to be found in a thorough understanding of the implications of rapid technological change. Such rapid change creates a cycle that erects barriers to entry. As businesses rapidly mature, leading competitors vie for a low cost position and harvest profits to reinvest in emerging businesses. As this cycle is repeated, and as each emerging business becomes more complex than its predecessor, companies wishing to enter the new business without an installed base and previous generations of products from which to harvest profits are at an increasing disadvantage.

What are now the simplest of technological applications were at one time on the leading edge and required significant R & D and applications engineering. At the early stage of business development, products designed by various competitors for a single market segment often have quite different features. Niches are much easier to find and sustain. As the technology applied in that business area becomes more standardized, however, the products become less easy to differentiate on the basis of product features. Whereas a small company with some technological capability could previously use design features to differentiate its product, standardization of the technology creates tremendous advantages for manufacturers with production and marketing scale, at the expense of the smaller companies. Thus, as the technology involved in a business matures, barriers to entry grow (See Exhibit VII.2).

EXHIBIT VII.2

TYPICAL COST DYNAMIC OF TELECOMMUNICATIONS EQUIPMENT BUSINESSES



Note: Costs are times ten in five years; new product generations are introduced every 2-3 years.
Source: John Elliot, Fellow Emeritus, Bell Northern Research, 1986.

Companies that wish to enter the lucrative and expanding telecommunications industry therefore realize that earlier entry is better, even if they have to sacrifice profits for some time in order to establish a position. The result is an extremely competitive environment in which even the largest players may sustain huge losses in entire business segments for several consecutive years.

The fact that entry barriers are rising would make the telecommunications industry rather unattractive for Canada were it not for the fact that we already have one of the world's largest telecommunications manufacturers operating largely out of Canada. The fact that such a major player—Northern Telecom—has developed in Canada is clearly exceptional, and there are lessons to be learned from this fortunate exception to Canada's otherwise dismal record in creating indigenous world-scale firms outside the natural resource sectors.

THE NORTHERN TELECOM EXPERIENCE

Northern Telecom Ltd. is a company that has succeeded in becoming an indigenous Canadian multinational manufacturer in the high growth telecommunications industry. More than ten percent of the company's 1986 sales revenues of U.S. $4,383 million was spent on research and development. Northern Telecom and its research organization, Bell Northern Research, have given rise to more than 50 spin-off companies. Northern Telecom is such a critical player that it is impossible to tell the story of telecommunications in Canada without dwelling on the development of this company.

The story of Northern Telecom's evolution from a small design "cloning" operation into a major multinational in a period of less than 30 years emphasizes the dynamic nature of the industry as a whole. It also points to the tremendous importance of managing technological progress, adopting appropriate strategies at each stage of a company's development, and gaining access to a sufficiently large market to achieve world-competitive manufacturing scale.

The rapid growth of Northern Telecom has been remarkable. Given the intense competition in this industry, however, it has taken more than luck and a high growth industry to achieve such phenomenal progress. The very fact that Northern Telecom is such a young organization may have provided some advantage in that it was more open than its competitors to new people and ideas. But the success of Northern Telecom must be attributed largely to its special access to a large domestic market and its ability to manage innovation and to identify and adopt appropriate strategies at various stages in its development. As the company has evolved through three technological stages, with a fourth stage imminent, its strategy also has evolved. The latest strategy requires even more complex research and managerial skills than those that were required to make Northern Telecom the world leader it is today[1] (See Exhibit VII.3).

Northern Telecom was the indirect creation of a 1956 U.S. anti-trust decision that severed the design links between Northern Electric, Bell Canada's equipment manufacturer, and AT&T. Rather than simply licensing foreign technology, Bell Canada and Northern Electric agreed to conduct their own research and development. The combined team of four researchers adopted a strategy of cloning, with slight improvements, existing technology for sale to one customer—Bell Canada. This strategy was at the centre of R & D efforts from 1958 to 1968.

As the R & D team grew and became more familiar with the needs of its customer and the evolution of technology, it began to

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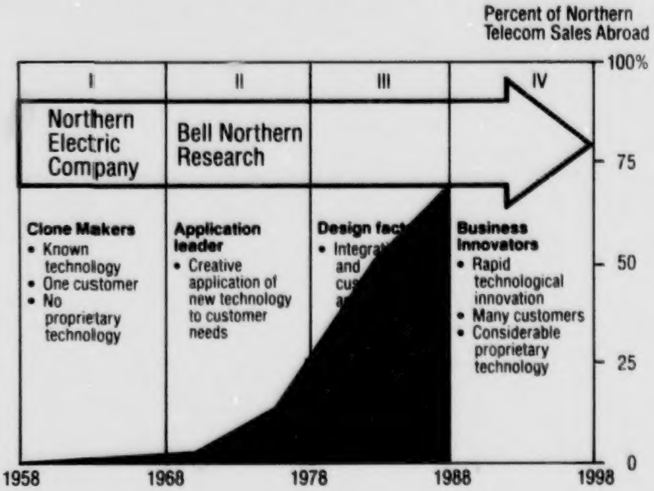
[1] The discussion of Northern Telecom's history in this chapter draws heavily on an interview with John Elliot, Fellow Emeritus, Bell Northern Research.

EXHIBIT VII.3

THE FOUR DESIGN ERAS IN NORTHERN TELECOM'S HISTORY



Source: John Elliot, Fellow Emeritus, Bell Northern Research and Telesis analysis.

explore innovative applications for existing technology. During this second era, which lasted from 1968 to 1978, the relatively small domestic market for the company's products dictated a strategy of committing its efforts to adopting a new technology only when its application and usefulness became indisputably clear.

Northern Telecom's success with its earlier strategies gave its management the confidence to take a major innovative risk in 1976. This was the large-scale launch of digital telecommunications systems, a technology that most of the world's telecommunications manufacturers believed would not be introduced for several years. At that time, Northern Telecom's small installed base actually proved advantageous. Because it was not as heavily committed as its larger competitors were to sales of analog technology, Northern Telecom was better positioned to make the leap to digital. As Northern Telecom proceeded to develop digital products for its small home market, an event in the United States created its next opportunity. AT&T, at that time the world's largest corporation, had its monopoly broken by a 1978 court ruling. The opportunity this presented to Northern Telecom ushered in its third stage of development: the design factory.

As a leading supplier of digital equipment, Northern Telecom developed an international customer base and had become a true world competitor, but its new position required an even more complex set of management skills. The new strategy involved balancing full lines of interconnected products at 'technology plateaus'. At the same time, because Northern Telecom was no longer selling to a captive customer, it had to become more market-oriented and internationally focussed. Digital innovation and appropriate strategies had made the company world-class, but this was only the beginning of competing successfully in the world arena. The strong position Northern Telecom has now achieved looks sustainable, but the pace of technological change and the profit potential of this high growth industry ensure that other large players will not ease the competitive pressures.

Today, Northern Telecom is moving into a fourth phase, requiring yet another re-thinking of its strategy. Its various business segments have been affected to different degrees by technological change, and Northern Telecom must now develop different sub-strategies in each of its businesses. Part of the company's overall strategy is greater involvement in more basic, pre-competitive research to develop new leading-edge technologies. Work in cooperation with the National Research Council in gallium arsenide, a new material with possible future applications in computer chips, is one example.

However, in the market for small office systems, where the technology is becoming more standardized and the degree of differentiation between products less pronounced, Northern Telecom has ridden the technology down the complexity curve. In the early stages of this business, Northern Telecom was a leader in product development and engineering, particularly in the high end of the market, but it has since turned its attention to cost-cutting through automation of manufacturing and vertical integration. The company has been so successful with this strategy that it now dominates the mid-range office switching market, with perhaps the lowest cost position in North America.

COMPETITIVE DYNAMICS

This discussion of the competitive dynamics of the telecommunications industry concentrates on the market for switching systems: public or central office systems (CO), private branch exchange systems (PBX), and key systems. Together these three segments accounted for 56 percent of world sales of telecommunications equipment in 1985, or about $14.5 billion (See Exhibit VII.4). The discussion is mainly limited to these businesses because Canadian companies have a strong presence in

EXHIBIT VII.4

WORLD TELECOMMUNICATIONS MARKET
U.S. $ Millions

Market Segments	1985 *Sales*
Public Switching (CO)	$8,000
Fibre Optic Cable	570
Fibre Optic Transmission	330
Satellite	1,250
PBX	4,075
Key Systems	2,400
Cellular Equipment	580
Cellular Phone	410
Phone Sets	4,200
Facsimile	750
Other Data Communication Devices	2,000
Total	U.S. $25,640

Source: Telesis analysis.

them and because they make the implications of rapid technological evolution very clear.

We begin with a discussion of the most complex systems, the central office switching systems, and end with an examination of the key systems business, which has a much lower technology content. The progression from complex to simple may defy the logic of a well-structured narrative, but it parallels the progression of businesses within an industry experiencing rapid technological change. Businesses once considered complex and at the leading edge of technology become standard as the technology involved becomes more widespread. Companies such as Northern

Telecom, that succeed in riding the technology down the complexity curve can harvest profits that will be invested in research and development of new businesses and technologies. These in turn will emerge initially as complex businesses, with profits to be reaped down the next complexity curve.

Public/Central Office Switching Systems

Central office switching (CO) systems are huge telephone systems, ranging up to 165,000 lines, and controlled by microprocessors. Prices per switch range from $500,000 to $15 million, and contracts are in the hundreds of millions of dollars. All equipment is sold directly to the end users—telephone operating companies.

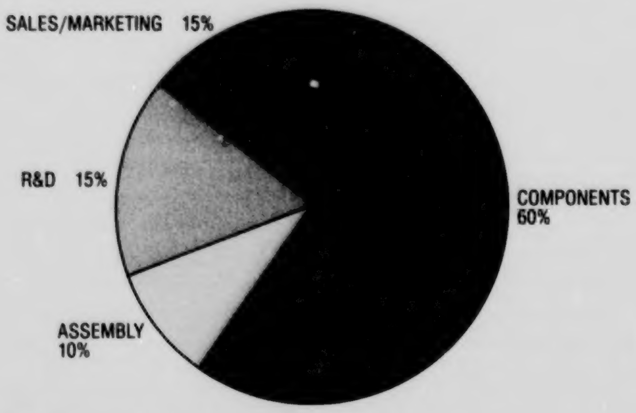
There are relatively few competitors in this business, and all are large because the huge R & D and component costs demand manufacturing scale. Most are also vertically integrated, even to the point of manufacturing their own chips. In 1985, Northern Telecom was the world's second largest supplier of CO systems after AT&T.

Many international markets for CO systems (as well as most other telecommunications equipment) are closed. Even if markets are open, indigenous suppliers often service a large portion of the market in their home country. The U.S. market represents 40 to 50 percent of the total world market and is the market that is most open to foreign competition. The remarkable success of Northern Telecom in the U.S. market is proof of the company's strength. Most markets in Japan and Europe are closed, with governments providing shelter to less competitive domestic companies. Many of the less developed countries are engaged in upgrading and expanding their telephone service, and China is viewed as the largest potential developed country market. Because of the size and complexity of these switches, as well as local content regulations, final manufacturing of the switches is usually done in the country where installation will take place.

The cost structure of a CO system reveals some of the key success factors in this business. R & D costs of 15 percent and assembly costs of ten percent indicate that this is more a research business than a manufacturing business (See Exhibit VII.5). Applications engineering to modify products to suit the needs of individual customers is a key to competition in this business. The second key is clearly to amortize huge R & D investments through sufficient sales. Because this is still a very customer-oriented business, products are differentiated and some are definitely superior to others. As the technology evolves, however, this should become a more standard price-sensitive business, somewhat more like the private branch exchange business. Lowering

EXHIBIT VII.5

CENTRAL OFFICE SWITCHES
PRODUCT COST STRUCTURE
Percent of Total Product Costs



Source: Based on industry interviews and analysis.

manufacturing costs will then become more important to company success. Those companies with a strong base of installed equipment will be in a position to harvest profits for investment in the development of new businesses.

Private Branch Exchange Systems

The $4 billion PBX business includes three distinct sub-segments: high-end systems with 400 lines or more, mid-range systems (100 to 400 lines), and the low end of the market—systems with fewer than 100 lines. The dynamics involved in these business segments illustrate even more clearly the impact of technology and the dangers involved for a company that is unable to ride the technology curve. The PBX market is a fiercely competitive business, with several large manufacturers holding significant market shares and 15 to 20 manufacturers attempting to gain market share.

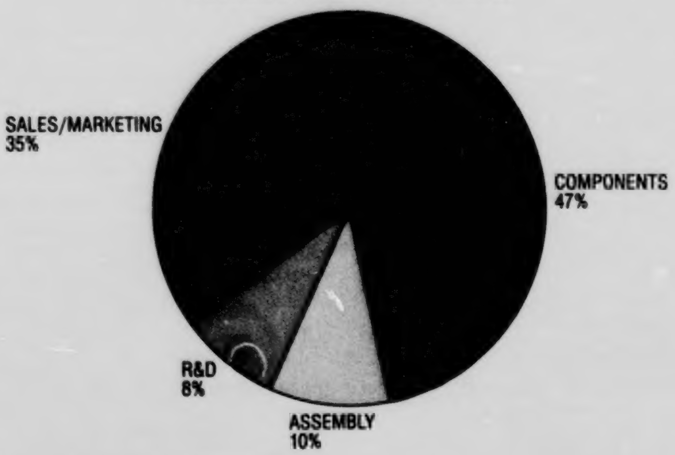
PBX systems are sold to business offices, hotels, and other customers who need a private telephone network. Forty percent of the market is in the United States, and since deregulation this market has become the main focus of competitive activity. Once again, the Japanese, French, and West German markets are generally closed; however, the U.K. market is heating up following deregulation, and the rest of the world is generally open to competition.

The cost structure of a PBX system is less weighted toward research and development than that of a CO system and involves much higher sales and marketing costs (See Exhibit VII.6). This is because the technology has become widespread and marketing activities have become more important to competitive success. As a result, products are not as highly differentiated as central office switches, particularly at the low end of the market, and price has become the principal purchasing criterion. Companies have also sought to differentiate themselves through aggressive marketing, product customization, and superior after-sales service, thus driving up marketing and sales costs.

Success in the high end of the PBX business revolves around scale in marketing, applications engineering, service follow-up, and product functionality. The emphasis on marketing and product customization has prompted at least one alliance between a technology-oriented company and a sales-oriented organization—the partnership of Rolm and IBM. It has also hindered the suc-

EXHIBIT VII.6

PRIVATE BRANCH EXCHANGES
PRODUCT COST STRUCTURE
Percent of Total Product Costs



Source: Based on industry interviews and analysis.

cessful entry of competition from low wage countries. However, as this segment matures and applications become more standardized, successful competitors are shifting their efforts towards developing a low cost position. Scale, efficient manufacturing, and vertical integration have made Northern Telecom probably the lowest cost competitor in the high end of the PBX market, resulting in a world market share of 25 to 35 percent.

Technological differentiation is no longer a factor in the low end of the market (fewer than 100 lines). The emphasis is now entirely on the lowest cost product. As a result, this end of the market has come under tremendous pressure from low wage manufacturers outside North America, and many manufacturers in Canada and the United States have been squeezed out by that competition.

One company that got caught in the middle of the market, between low wage competitors and high-end companies riding down the complexity curve is Mitel. This Ottawa-based company had concentrated its efforts and gained market share in the low and middle segments of the market, with good products and distribution through supply houses. As the company experienced pressure from competitors at either end of the market, it took a giant leap up-market with the introduction of the SX-2000, a product with a capacity of 400 lines or more. Unfortunately, Mitel was late to enter the market and had not yet developed the sales and marketing capabilities necessary to sell in the higher end of the market. As a result, the SX-2000 has not done well, and Mitel has written off much of its R & D investment in that product.

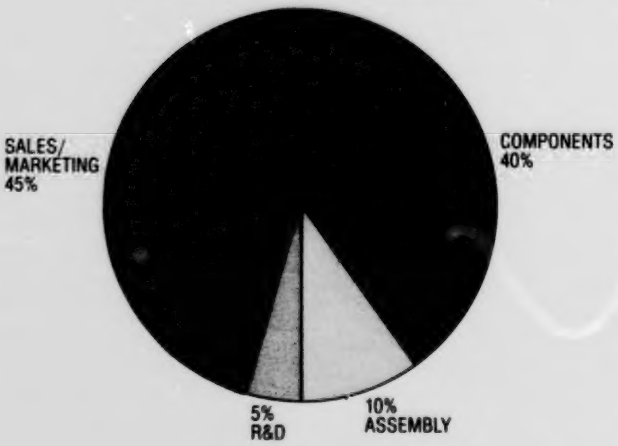
Key Systems

Key systems are even less sophisticated in most cases than the low-end PBXs. In fact, various hybrid products have been developed that effectively blur the line between key and PBX systems. Canadian companies have little involvement in this business, which was worth $2.4 billion worldwide in 1985.

Only five percent of the cost structure of a key system is accounted for by R & D, while 45 percent is made up of sales and marketing costs (See Exhibit VII.7). Because key systems are considered a commodity product, more than 70 percent of which are sold through distributors, low wage foreign competitors have a significant cost advantage and are not constrained by the need to build a marketing organization. Most of the North American companies that have remained competitive in this market have moved their manufacturing operations to lower wage locations outside North America.

EXHIBIT VII.7

KEY SYSTEMS
PRODUCT COST STRUCTURE
Percent of Total Product Costs



Source: Based on industry interviews and analysis.

IMPLICATIONS FOR THE FUTURE

Although analysts can confidently project continued growth in the telecommunications industry, the exact direction of that growth is highly uncertain. Technology is expected to progress at its current pace, and software development will continue to become a larger part of the total cost of a product. Barriers to entry will continue to grow in the high-end businesses, and the low-end businesses will become increasingly dominated by competition from low wage manufacturers.

To take advantage of its established position, a large company such as Northern Telecom must reap profits from its older, less sophisticated equipment lines and must invest in the development of new products, often in entirely new businesses. By anticipating and entering new telecommunications businesses in their early stages, established companies like Northern Telecom can preserve their installed bases, ride the technology curve, and use their profits to prepare for the next generation of products. In the absence of serious blunders, this cycle of products and technological change will sustain the position of today's leaders in telecommunications equipment manufacturing. It is also this cycle that, with every repetition, increases the barriers facing other smaller telecommunications firms trying to improve their competitive positions.

Despite the favourable position of Northern Telecom and the success of the many smaller firms that it has spawned, both directly and indirectly, Canada's telecommunications industry continues to have needs. Given that this is one of Canada's most promising industries in terms of growth potential, export performance, and value-added, it is imperative that these needs be met.

There is, first of all, the need for a continuous supply of top quality university graduates, particularly in the software field. Northern Telecom and Bell Northern Research alone hire 500 engineering graduates from Canadian universities each year, many from the University of Waterloo. The industry acknowledges that the university system is providing competent undergraduates and superb graduate students, but excellence in the education system continues to be a top priority for the telecommunications industry.

We have already come to understand the importance of large, properly targeted investments in research and development. In many other countries, the R & D activities of telecommunications companies are subsidized more directly. Although some larger companies such as Northern Telecom are very sensitive to the issue of direct government subsidies (other than R&D tax credits) and will resist them, they do recognize the need for more precompetitive research. Cooperative research efforts with the public sector, such as the gallium arsenide project, would likely be welcomed if they gave Northern Telecom an advantage in preparing to compete in anticipated new businesses.

Although this chapter has concentrated on the largest of the Canadian telecommunications competitors, the needs of the many spin-off firms that give the Canadian telecommunications industry such vitality are no less important. These companies are facing much the same kinds of problems as firms starting up in other emerging and high growth industries. The nature of these challenges is thoroughly examined in other chapters of this volume and Volume 1 of the Premier's Council Report.

CHAPTER VIII
THE AEROSPACE INDUSTRY

THE WORLD INDUSTRY

Together with the telecommunications industry, the aerospace industry is one of the success stories among Canada's established high growth industries. Its success is evident in the fact that a complete aerospace industry exists in Canada, including diversified multinationals, niche or single-product companies, and a network of sub-suppliers. There is also a healthy contingent of Canadian-owned firms at all levels in the sector.

Although Canada is a net importer of aircraft, Ontario is a net exporter, in part because of labour cost advantages and the existence of several strong indigenous firms. Ensuring that the Ontario aerospace industry continues to grow and generate wealth for the province will depend on the ability of all firms to maintain and expand their competitive advantages in a world market where significant change is already underway.

Since World War II, the United States has been the leader in the free world aerospace industry. The advantages enjoyed by U.S. competitors in terms of defence-related R & D expenditures and preferred access to the world's largest market have translated into a 65 percent share of the world market for aircraft. Recently, however, smaller countries have made inroads in several of the markets that were traditionally the near-exclusive preserve of U.S. manufacturers. To understand the reasons for this shift and the opportunities it presents for Canada, the next section contains a discussion of the world aerospace industry, followed by an explanation of the industry's competitive dynamics.

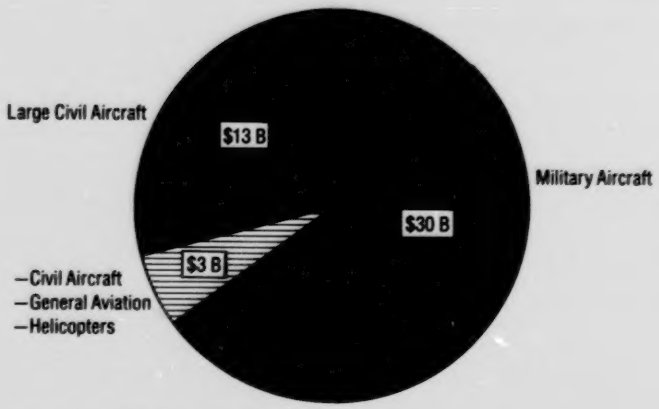
WORLD INDUSTRY AND MARKET STRUCTURE

The free world market for aircraft was $46 billion in 1986. The largest share of the market was military aircraft, which accounted for $30 billion, followed by large civil aircraft at $13 billion, and $3 billion for small civil aircraft, general aviation aircraft and helicopters (See Exhibit VIII.1). In other words, less than 35 percent of the total world aircraft market consisted of non-military aircraft.

Until recently, the United States held a commanding lead in the manufacture of military aircraft and systems and large civilian aircraft, as well as in the propulsion, avionics, and space

EXHIBIT VIII.1

FREE WORLD AIRCRAFT MARKET
$46 Billion
1986



Source: U.S. Industrial Outlook, Financial Times

industries. In fact, the United States still manufactures 69 percent of all aircraft sold in the free world.

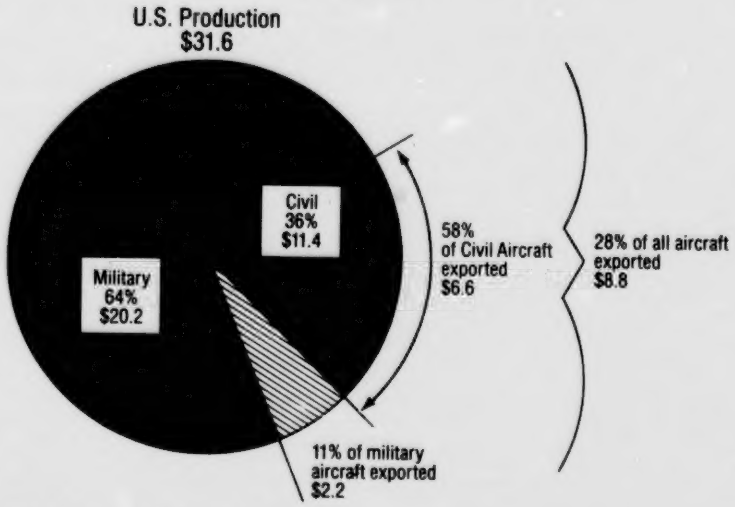
Approximately two-thirds of U.S. aircraft production is for military applications (See Exhibit VIII.2). Of these military products, the vast majority remain in the United States; only 11 percent of the military aircraft produced are exported. Of the $11.4 billion worth of U.S. shipments of civil aircraft in 1985, approximately 58 percent or $6.6 billion was exported. In total, $8.8 billion worth of aircraft production was exported from the United States in 1985. These figures confirm that U.S. manufacturers, with a three-quarter share of the $16 billion civil aircraft market and a two-thirds share of the $30 billion military aircraft market, are the dominant force in the world aerospace industry. Nevertheless, several trends are acting to alter the structure and competitive dynamics of the industry.

DECLINING U.S. DOMINANCE

Despite the apparent domination of the world aircraft industry by the United States, the industry is becoming more global as manufacturers in other countries challenge U.S. producers in foreign and U.S. markets for large civilian aircraft, small civilian aircraft, and space equipment. Several of these countries have had

EXHIBIT VIII.2

1985 U.S. AIRCRAFT SHIPMENTS
U.S. $ Billion



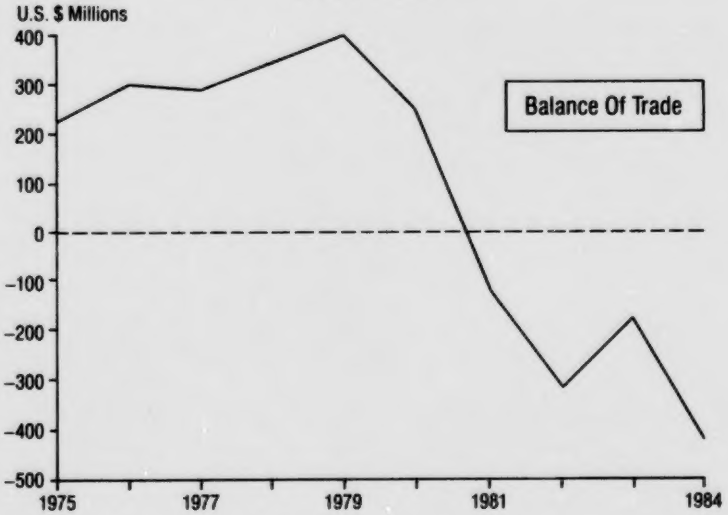
Source: U.S. Industrial Outlook, Financial Times.

aerospace industries for some time, but until recently their focus had been mainly on meeting local defence needs, building small civilian aircraft, and manufacturing components and systems under offset agreements with U.S. defence contractors. Recently, however, new products—such as the European Airbus in the large civilian aircraft market, new aircraft from several countries in the small civilian aircraft market, and the European Ariane space project—have challenged the United States in many of its most lucrative aerospace business sectors.

With a 77 percent share of the free world's large commercial aircraft production in 1980-84, there could be no doubt that U.S. manufacturers were still leaders in the large aircraft market segment. However, in the last few years the European Airbus consortium has steadily been gaining market share and increasingly challenging U.S. leads. In the much smaller $1 billion civil aircraft market, competitors such as Fokker of the Netherlands, Aerospatiale of France and Italy, Short Brothers of Ireland, and De Havilland of Canada have successfully challenged the market share traditionally held by U.S. manufacturers. As a result of these

EXHIBIT VIII.3

U.S. TRADE IN GENERAL AVIATION AIRCRAFT (1975–1984)



Source: Telesis analysis of U.S. trade data, 1987.

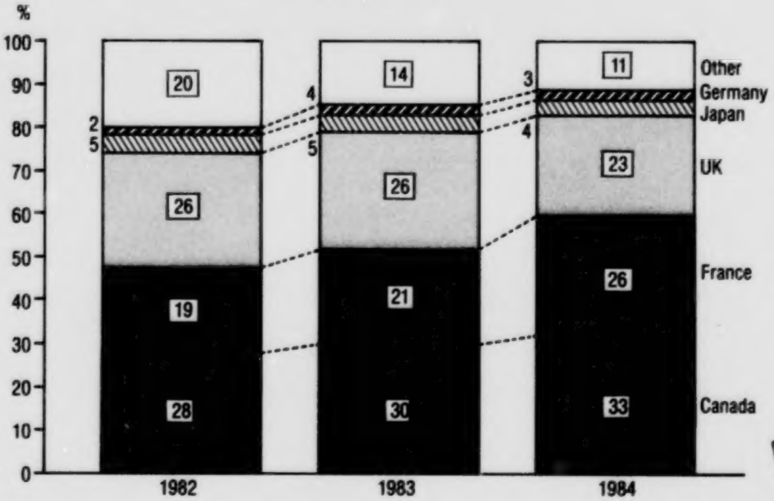
successes, the United States had become a net importer of small civil aircraft by 1981 (See Exhibit VIII.3).

As a result of the successes of foreign firms competing aggressively in the U.S. market, that country has become a modest but significant importer of large and small civil aircraft. By 1985, 24 percent of the $6.2 billion U.S. market for civil aircraft was held by imports. Canada, France, and the United Kingdom have become the major aerospace exporters to the United States. Canada is the largest of these exporters, with a 33 percent share of aerospace products imported into the United States in 1984 (See Exhibit VIII.4).

In addition to these competitive shifts in the market for completed aircraft products, competition in aircraft components, avionics, and other sub-systems has become truly global. Even countries that have no major aircraft manufacturers, such as Japan, have become strong in these supply industries. The competitive positions of various countries in the production of aircraft and parts are shown in Exhibit VIII.5.

EXHIBIT VIII.4

U.S. AEROSPACE PRODUCTS IMPORTS
(% Market Share)



Source: Telesis analysis of U.S. trade data, 1987.

The United States continues to dominate the aircraft and parts industries, with an extremely high ratio of exports to imports and the highest value-added per employee of the countries ranked. Other countries, such as France and the United Kingdom, are also net exporters of aircraft and parts but have lower value-added per employee. Although Canada appears in Exhibit VIII.5 as a net importer of aircraft and parts, avionics was not included in the analysis; however, it is one of Canada's strong product areas. Ontario is a net exporter of aircraft and parts, although the value-added per employee in the Ontario industry is somewhat less than that for Canada as a whole and much less than that of countries like the U.S., France, and Germany. This low value-added per employee performance illustrates the strong presence in the Ontario industry of lower skill satellite branch plants owned by major aerospace multinationals.

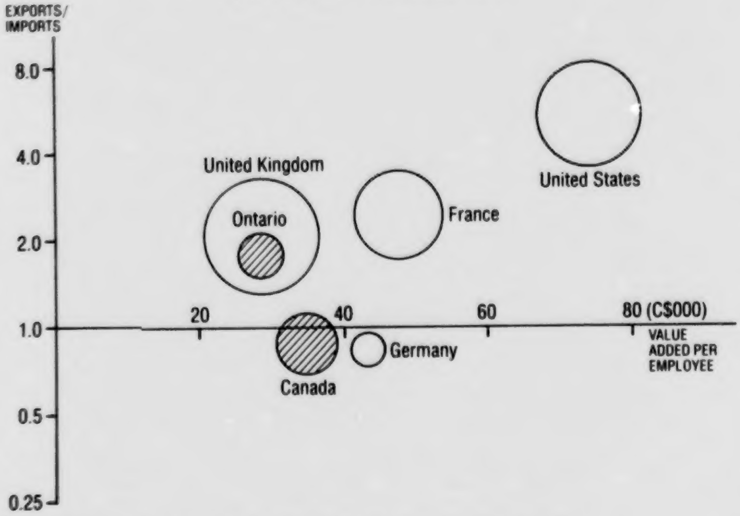
COMPETITIVE DYNAMICS

International competition in aerospace revolves around technological, political, and market share factors. Technological capa-

EXHIBIT VIII.5

RELATIVE COMPETITIVENESS OF MAJOR AEROSPACE INDUSTRIES—1983

(Excluding Avionics)
(at 1986 Exchange Rates)



Circle diameter corresponds to percentage of manufacturing work force involved in aerospace:
U.K. = 3.5%, U.S. = 3.1%, France = 2.7%, Canada = 1.8%, Ontario = 1.3%, Germany = 1.0%
Source: Telesis analysis based on individual country statistics and U.N. Trade Statistics Year Book

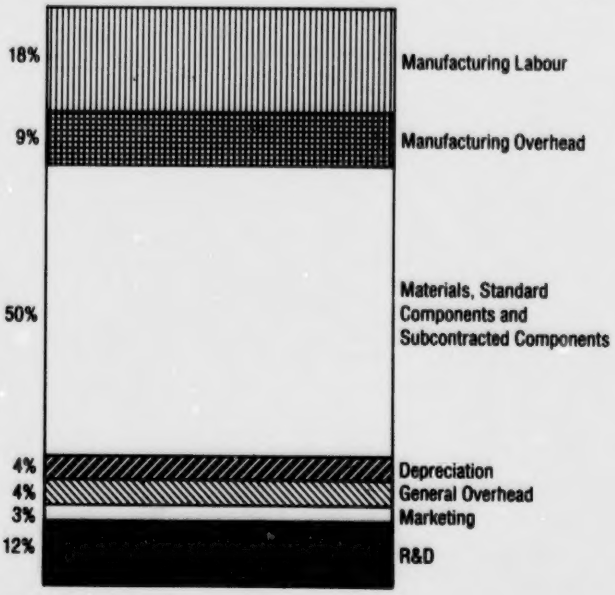
bility is critical in gaining entry to the aerospace industry, and in some cases products can be differentiated on a technological basis. In most business segments, however, the key success factor is gaining adequate product sales to amortize the huge fixed costs associated with research and development and the launch of new products. This can be achieved by gaining a high market share and long individual product runs, which in turn can result from a combination of advanced technological capability, product reliability, service to customers, aggressive pricing policies (based on the expectation that cost reductions will occur as the company moves along the experience curve), and a willingness to meet the political needs of buyers. These political needs can include offset purchases in the customer's home country, local content provisions, and technology transfer arrangements. All military sales and most civilian sales outside North America entail such political requirements.

In most companies, military projects provide a technological and financial cushion to support civilian aerospace activities. Military work is often performed on a cost-plus basis, so contractors cannot lose money. The relatively risk-free profits from military work also enable firms to take on the extremely high risk of civilian projects while maintaining an acceptable overall risk profile. The U.S. military, along with that of other countries, subsidizes R & D, tooling, and other product launch costs related to defence purchases, thereby providing significant benefits for aerospace producers in those countries because skills and technology developed on military projects can create competitive advantages for civilian manufacturers. These companies can also realize economies of scale in amortizing the large fixed costs of R & D across related products, both civilian and military.

Apart from these political factors, the competitive dynamics of individual businesses in the aerospace industry vary with their cost structures. Exhibits VII.6 to VII.9 show how factors such as

EXHIBIT VIII.6

A PROPRIETARY AVIONICS SYSTEM COST STRUCTURE



Payroll = 50% of total costs
Source: Telesis interviews and analysis.

scale, relationships with suppliers and subcontractors, and manufacturing productivity play different roles in the competitive success of aerospace companies in various segments of the industry.

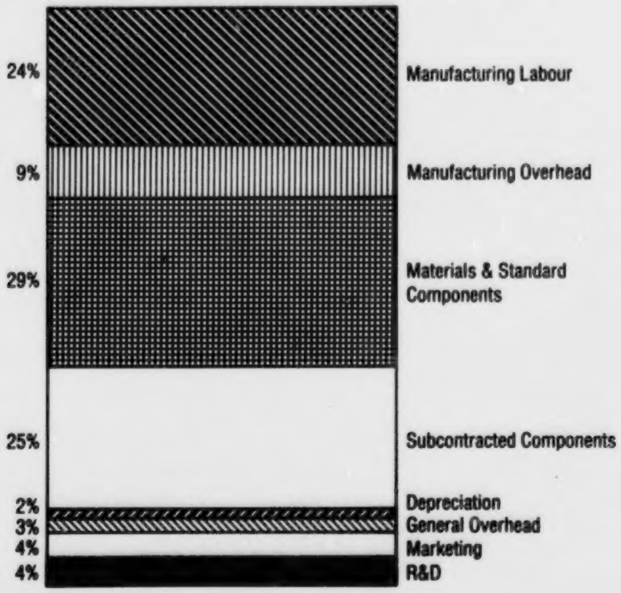
In the proprietary avionics segment, R & D is a significant cost component, and a company's ability to amortize the cost of research and development can be a significant competitive advantage (See Exhibit VIII.6). Thus, in this segment achieving the scale and market share required to amortize R & D costs over a large number of units is a key factor in competitive success.

For some proprietary products, such as the complex air frame components in Exhibit VIII.7, subcontracted specialized components can be a critical cost factor. In this business, maintenance of strong relationships with skilled suppliers and subcontractors can be a key success factor.

In non-proprietary components, such as air frame components produced by subcontractors, cost competitiveness is driven largely by manufacturing labour costs and productivity (See

EXHIBIT VIII.7

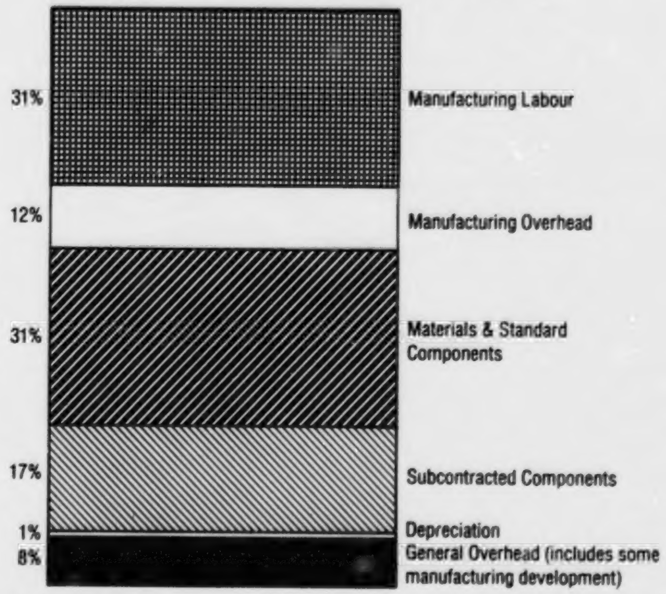
A COMPLEX PROPRIETARY AIR FRAME COMPONENT COST STRUCTURE



Payroll – 50% of total costs
Source: Telesis interviews and analysis.

EXHIBIT VIII.8

A LARGE (SUBCONTRACTED) AIR FRAME COMPONENT COST STRUCTURE



Payroll = 50% of total costs
No Marketing
Source: Telesis interviews and analysis.

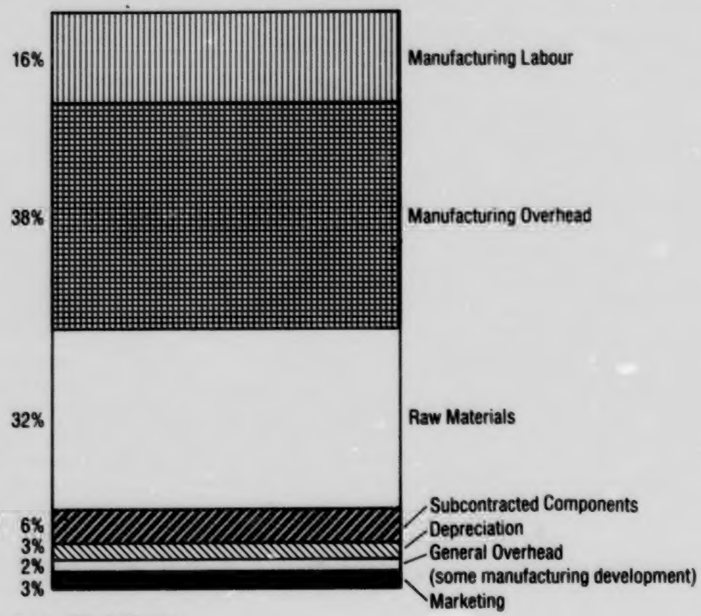
Exhibit VIII.8). Absent from this cost structure, of course, are marketing costs, as the products made by companies in this segment are manufactured under subcontract to proprietary prime contractors, which are responsible for marketing and promotion to the end user.

In some specialty components (for example, a specialty machined engine component) cost competitiveness can be driven by manufacturing overheads, which contain skilled and indirect labour and engineering costs. The cost structure for such a specialty machined component is shown in Exhibit VIII.9.

In those industry segments where labour costs are an important competitive factor, Canada and other lower wage countries enjoy competitive advantages relative to the United States. The labour rate for a U.S. aerospace production worker (in Canadian dollars) is $22.77 per hour, whereas the equivalent Canadian rate is $16.32 (See Exhibit VIII.10). This relatively less expensive

EXHIBIT VIII.9

A SPECIALTY MACHINED ENGINE COMPONENT COST STRUCTURE



Payroll = 50% of total costs
Source: Telesis interviews and analysis.

EXHIBIT VIII.10

AEROSPACE PRODUCTION WORKERS' LABOUR RATES
C$/Hour Including Benefits

	1985	Index
United States	$23.77	146
Canada	$16.32	100
Germany	$15.09	92
France	$13.65	84
United Kingdom	$10.05	62

Source: UN International Trade Statistics.

Canadian labour provides particularly significant cost advantages to manufacturers of subcontracted specialized components and non-proprietary components, where manufacturing labour represents 24 percent and 31 percent of total costs respectively.

R & D costs for aerospace products are significant and require long production runs if companies are to recoup their investments. Exhibit VIII.11 illustrates the number of units required to break even on the development of several major aerospace products. In these cases, gaining a large share of the market for that product is clearly the key to competitive survival and prosperity.

These high R & D and product launch costs make the prime civilian aerospace business very risky. The cost of developing and launching a new jet liner is $2.5 billion, and the net margin for large commercial aircraft is only three to four percent. Airbus Industrie, for example, has accumulated U.S. $10 billion in negative cash flow in its A300-310 program. Lockheed abandoned civil aircraft production in 1985 after the company managed only 223 sales of its L-1011 Tristar and suffered a negative cash flow of U.S. $6.7 billion. The riskiness of this business means that countries where aerospace manufacturers are subsidized indirectly through military work have a tremendous advantage. Military work stabilizes the manufacturer's risk base and enables a company to pursue export markets from a stronger domestic position.

CANADA'S AEROSPACE INDUSTRY

Canada has a sizable and healthy aerospace industry, with 55 percent of its production occurring in Ontario. This section looks at the structure of the industry and the position of companies within it relative to their competitors on the world market.

Industry Structure

The Canadian aerospace industry is made up of four types of companies: the large proprietary prime aircraft contractors, such as Canadair and Pratt & Whitney; the proprietary sub-prime contractors, like Litton Aerospace and Leigh Instruments; the satellite branch plants, including Bell-Textron and Boeing; and the component makers, processors, and fabricators, such as Devtek and Fleet Aerospace.

These four groups of companies vary in terms of their share of total Canadian aerospace production, the extent of foreign ownership, and their levels of spending on research and development (See Exhibit VIII.12). Companies in these groups are also distinguishable on the basis of the products they make, the markets

EXHIBIT VIII. 11

APPROXIMATE COSTS TO DEVELOP MAJOR AEROSPACE PRODUCTS

	Costs ($ Millions)	Break-even Point
150 Seat Commercial Airliner	$3,000	400 Units
Small commercial aircraft development (tooling and launch costs)	$500 600 ($250)	400 Units
Additional version of above aircraft	$100	N/A
Canadarm for NASA	$100	N/A
Navigational system (missile) manufacturing start-up only (no R&D)	$55	1–1½ Years
Proposal, design, tooling for aircraft component	$26	2 Years

Source: Telesis company interviews and published sources.

EXHIBIT VIII.12

STRUCTURE OF THE CANADIAN AEROSPACE INDUSTRY

	No. Of Firms	Share of Total Canadian Production	% Of Sales From Foreign-owned Firms	R&D As % Of Sales	Examples
Proprietary Prime Contractors	6 in Canada, of which 3 HQ in Ontario	$1.8 Billion (44% of Total)	57%	8–12%	Pratt & Whitney Canadair De Havilland CAE Spar Raytheon
Proprietary Sub-Prime Contractors	20 in Ontario	$1.3 Billion (32% of Total)	80%	10–15%	Garrett Litton Marconi Dowty Menasco Leigh
Satellite Branch Plants	10–15 in Ontario	$700 Million (17% of Total)	> 90%	Small	Bell-Textron Boeing McDonnell Douglas MBB
Component Makers, Processors, Fabricators	45–50 in Ontario	$300 Million (7% of Total)	Small	Little to None	Chicopee Fleet Devtek Haley Industries Walbar Bachan Aerospace

Source: Air Industries Association of Canada.

EXHIBIT VIII.13

COMPETITIVE DRIVERS BY AEROSPACE INDUSTRY SEGMENT

Industry Segment	Sample Products	Markets	Key Competitive Drivers
Proprietary Prime Contractors	• Aircraft • ATC Systems • Flight Simulators	International/Mostly Civilian	• Product differentiation • Development & launch amortization • Political considerations
Proprietary Sub-Prime Contractors	• Landing Gear • Navigation Systems • Radars	International/Mostly Military	• Product differentiation • Technical relationship with prime contractors • Offset requirements
Branch Satellite Plants	• Helicopters • Avionics • Aircraft Parts	International/Parent Company	• Offset driven
Component Makers, Processors, Fabricators	• Aircraft/Air Frame Assemblies • Engine Parts • Electronic Components • Machining, Heat Treat	Mainly Canadian	• Offset driven • Production management • Unique production

Source: Telesis analysis based on interviews.

they sell to, and the factors that are central to success in their particular industry segment (see Exhibit VIII.13).

Driven largely by contract offsets, many of the small component makers and branch satellite plants are located in Ontario. The component makers, with sales of approximately $300 million, number from 45 to 50 in Ontario. They make few foreign sales and do very little research and development. They do, however, employ a good deal of manufacturing labour, so production management and lower Canadian labour costs can provide advantages in this segment. Also driven by offset agreements are the branch satellite plants. There are ten to 15 of these in Ontario, with sales of approximately $700 million. These companies export a great deal of their product and often have world product mandates from a parent company, but they generally make only small components or parts of a product line, which they then sell to the parent company.

Ontario's proprietary prime and sub-prime contractors compete directly in the world market. Proprietary prime contractors, which sell approximately $1.8 billion in aerospace products annually, number only three in Ontario. This concentration and the relatively higher proportion of international sales are consistent with the need to develop scale in order to amortize their large research and development and product launch costs.

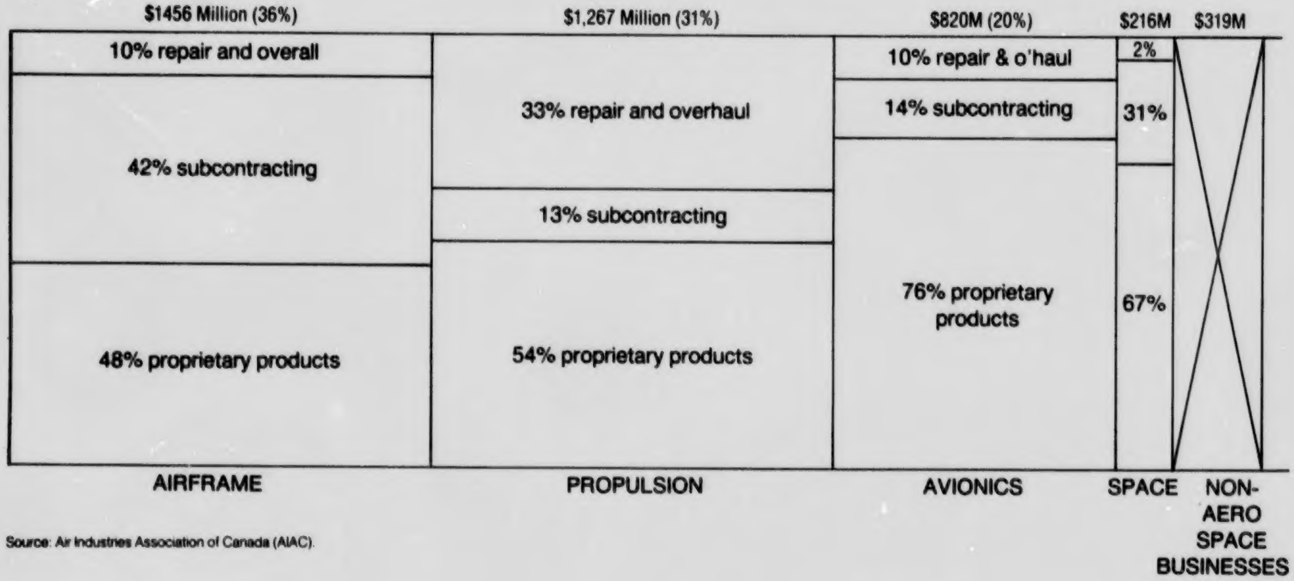
A large proportion of the cost structures of proprietary sub-prime companies is also accounted for by R & D, but they are not as concentrated as the proprietary prime contractors. The 20 sub-prime contractors in Ontario produce $1.3 billion in sales annually. The fact that they export approximately 80 per cent of their sales gives them the opportunity to achieve the scale required to amortize R & D costs. Proprietary sub-prime contractors are also partially driven by offset requirements.

In addition to these four types of companies, the Canadian aerospace industry can be divided into four functional segments: airframe, propulsion, avionics, and space products. Within these segments, Exhibit VIII.14 illustrates the relative positions occupied by proprietary products, subcontracting, and repair/overhaul. Clearly, avionics and space products, the two smaller segments, are those where Canadian manufacturers produce a large proportion of proprietary products.

In Canadian avionics products, which are electronic components for aviation applications, Ontario clearly dominates (See Exhibit VIII.15). This segment of aerospace is a strong one for Ontario and one in which a good deal of the product is proprietary. The Canadian military aerospace industry, with annual sales of $1.4 billion, is dominated by Ontario and its successful

EXHIBIT VIII.14

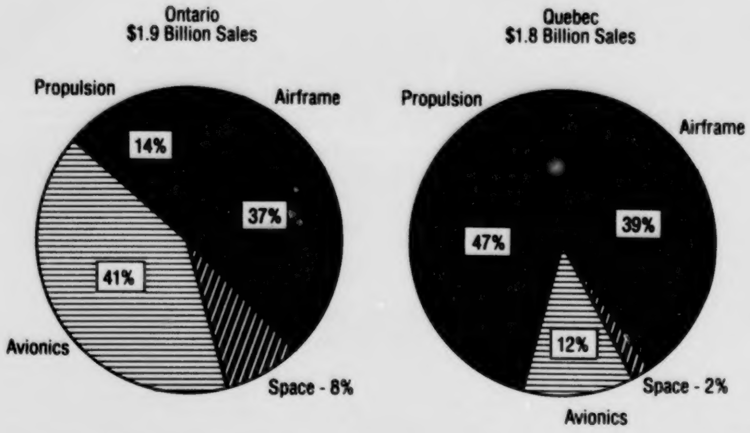
1985 CANADIAN AEROSPACE COMPANIES BUSINESS MIX
($4.1 Billion)



Source: Air Industries Association of Canada (AIAC).

EXHIBIT VIII.15

ONTARIO & QUEBEC AEROSPACE BUSINESS MIX
1985



Source: Air Industries Association of Canada (AIAC).

defence avionics industry. Ontario manufacturers account for 55 percent of Canadian military aerospace production (See Exhibit VIII.16). In the propulsion sector of the industry, Quebec's Pratt & Whitney dominates. Forty-seven percent of Quebec's $1.8 billion in annual aerospace sales was accounted for by sales of propulsion equipment.

Individual companies in the Canadian aerospace industry owe their existence to a variety of competitive factors. Some Canadian firms, such as De Havilland and Pratt & Whitney, have a long history as independent proprietary prime aerospace contractors competing in world markets from Canada. Others such as McDonnell-Douglas maintain Canadian operations mainly because of offset requirements. Many Canadian-owned and a few foreign component manufacturers have been nurtured through offsets but are now on the threshold of becoming internationally competitive firms selling on their own merits. These threshold firms represent some of the most exciting growth opportunities in the industry.

INDUSTRY PERFORMANCE

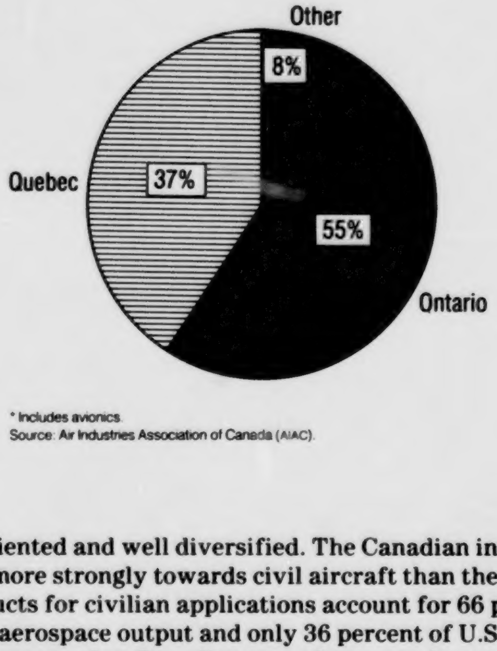
The Canadian aerospace industry is strong and sizable. Its 1985 sales amounted to $4.1 billion, including whole aircraft, components, engines, and avionics. The industry is largely

EXHIBIT VIII.16

1985 CANADIAN MILITARY AEROSPACE SALES*

$ 1.4 billion

Sales



* Includes avionics.
Source: Air Industries Association of Canada (AIAC).

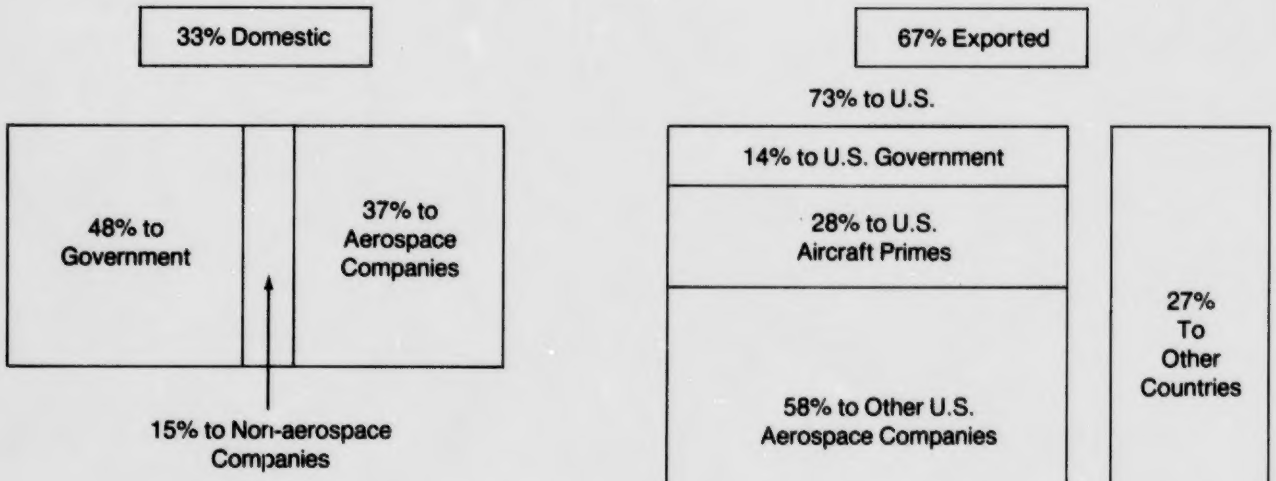
export-oriented and well diversified. The Canadian industry is oriented more strongly towards civil aircraft than the U.S. industry. Products for civilian applications account for 66 percent of Canada's aerospace output and only 36 percent of U.S. production. This means that Canadian manufacturers do not have the same risk-reduced military base upon which to build businesses as proprietary prime contractors of large civil aircraft in the U.S. do.

Of the 67 percent of Canadian aerospace production that was exported in 1985, 73 percent, or just over $2 billion, was shipped to the United States. Of this $2 billion, 58 percent went to U.S. aerospace companies, 28 percent to U.S. aircraft prime manufacturers, and 14 percent to the U.S. government (See Exhibit VIII.17). Of the 33 percent of Canadian production that stayed in Canada, 48 percent went to the government of Canada, 37 percent to aerospace companies, and 15 percent to non-aerospace companies. The U.S. market is obviously very important to Canadian aerospace production, as is foreign trade in general.

The success of these export-oriented companies and the general competitiveness of the industry are evident in the fact that

EXHIBIT VIII.17

CANADIAN AEROSPACE PRODUCTION
1985
$4.1 Billion


33% Domestic
67% Exported
73% to U.S.
48% to Government
37% to Aerospace Companies
15% to Non-aerospace Companies
14% to U.S. Government
28% to U.S. Aircraft Primes
58% to Other U.S. Aerospace Companies
27% To Other Countries

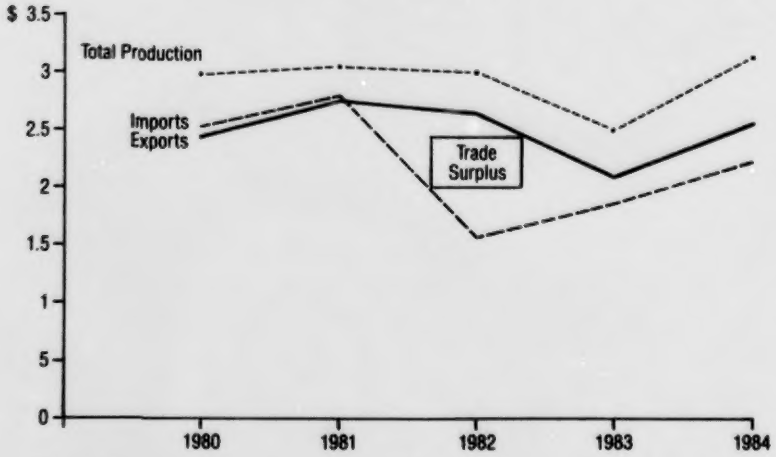
Source: Air Industries Association of Canada (AIAC).

Canada has enjoyed a modest trade surplus in aerospace (including avionics) since 1981 (See Exhibit VIII.18). Ontario manufacturers have been particularly successful; 47 percent of the Canadian industry is now based in Ontario. In a reasonably free marketplace, this is an indication that in many cases Ontario is the location of choice for aerospace manufacturers.

Although the competitive dynamics and success factors vary among segments of the aerospace industry, it is possible to summarize the general competitive advantages and disadvantages of the Canadian aerospace industry relative to its U.S. competition. Among the advantages for Canadian firms are engineering costs, which are usually about 23 percent less than those in the United States, lower hourly labour costs, and Canadian defence procurement offset policies. However, these competitive advantages may be outweighed by the disadvantages of a small domestic market, low military spending, relatively low government R & D levels, non-tariff barriers in the U.S. market, the lack of major prime contractors in Canada, and the absence of integrated proprietary producers in the country.

EXHIBIT VIII.18

CANADIAN AEROSPACE INDUSTRY TRADE PERFORMANCE
(1984 Cdn. $ Billions)



*Includes avionics but not non-aerospace sales of aerospace companies
Source: Department of Regional Industrial Expansion.

THE ROLE OF GOVERNMENT

Because governments account for such a large proportion of aerospace equipment purchases, they have traditionally taken a fairly active role in aiding the development of domestic aerospace industries. Government procurement has proven to be an effective and easily acceptable lever for industrial development. In fact, the existence of whole segments of Canada's aerospace industry can be attributed to government offset policies.

Federal Policy

Federal policy is influential in promoting the Canadian industry on several levels. Direct funding by the Department of Regional Industrial Expansion amounted to $169 million in 1985-86. Government policy also requires offset or other economic benefits to Canada from all companies exporting military equipment to Canada. In addition, the Canadian Commercial Corporation has provided assistance to smaller companies in aircraft, space, and propulsion. Finally, the government made direct aerospace purchases of $646 million in 1985-86.

Major offset programs supporting the aerospace business in Canada include the recent purchase of $3.2 billion worth of CF-18 aircraft, a contract for which the federal government secured an offset value of 122 percent. Ontario leads all other provinces in its share of this $3.9 billion offset package. Other offset value agreements have ranged from 62 percent to 133 percent of the value of the contract (See Exhibit VIII.19).

Another source of government support for the aerospace industry is defence purchases. Recent major aerospace projects initiated by the Department of National Defence have a combined value close to $2.3 billion and range in size from the tactical air navigation system, with a contract value of $40 million, to the North American Air Defence Modernization Program, with a contract value of $840 million (See Exhibit VIII.20).

There are several formulators and executors of Canadian defence procurement policy, including the departments of National Defence, Supply and Services, External Affairs, and Regional Industrial Expansion, and the Canadian Commercial Corporation. Overall, Canada is a relatively low defence spender, spending only 2.1 percent of Gross Domestic Product on defence. When countries are ranked by the size of their defence budgets as a percentage of GDP, Canada is next to last among the NATO countries. This is less than half the proportion of GDP spent by Greece, the United States, the United Kingdom, Turkey or France. Because of Canada's relatively large GDP, however, the actual defence budget ranks sixth among the NATO countries.

EXHIBIT VIII.19

MAJOR OFFSET PROGRAMS PROVIDING SUPPORT TO CANADIAN AEROSPACE INDUSTRY

Program	Contract Value $ Millions	Offset Value	Other Benefits
CF-18 Aircraft	$3,200	122%	Ontario leads other provinces in $3.9 billion offset package
Canadian Patrol Frigate	$2,900	62%	Ontario gets 27% of package
Long Range Patrol Aircraft	$900	133%	Ontario received 47% of $1.2 billion package
Radar Modernization	$390	100%	Ontario gets 30%
Helicopter Manufacturing	$34	N/A	Located in Ontario

Source: DRIE/Defence Industry Productive Program

EXHIBIT VIII.20

MAJOR NATIONAL DEFENCE AEROSPACE PROJECTS

Program	Prime Contractor	Contract Value ($ Millions)	Specifics
North American Air Defence Modernization (Ground-based)	Raytheon	840	Ongoing Program
ADATS	Oerlikon	600	Low Level Air Defence System
NATO Airborne early warning	None	330	Aircraft for NATO airforce
Challenger	Canadair	183	12 Aircraft
Dash 8	De Havilland	98	6 Aircraft
CF 18 Missile	3 in U.S.	80	Air to air missile for CF 18
Space Systems	N/A	48	Research only into high frequency communication
Tactical Air Navigation (TACAN)	Leigh Instruments	40	40 Beacons plus 20 optional

Source: Canadian Department of National Defence, 1986.

Of all these Canadian defence procurement programs, only the Low Level Air Defence System (ADATS) represents a significant opportunity for Canadian military aerospace exports. As with most other competitive international projects, a consortium of companies was involved. The participants included Oerlikon, Litton, Devtek, Spar, and CAE, among others. The original Canadian order was for $600 million, but the potential U.S. market is at least ten times as large. In fact, the Oerlikon ADATS system has the potential to replace the mechanically and politically troubled Sergeant York defence system in the United States.

The Defence Production Sharing Agreement is the basis for defence trade between Canada and the United States. This agreement was established in 1959 to "continue the principle of economic co-operation in the interest of continental defence". Although the agreement opens the door to Canadian supply of U.S. defence needs by eliminating cross-border duties, Canada still provides less than one percent of U.S. defence needs. In general, Canada will get a U.S. defence-related R & D contract only when it has clear product leadership. There are several reasons for this: some areas of defence spending are simply off-limits to non-U.S. suppliers; domestic politics in the United States still heavily influences contracts; and there is a U.S. perception of Canada as an inadequate defence spender.

Despite these limitations, the federal Defence Industry Productivity Program (DIPP) is one of the few assistance programs that focus on a specific industry primarily to strengthen its export capabilities. The objective is to help Canadian companies compete in relatively risky defence-related enterprises against foreign companies, which are often directly aided or subsidized by their governments. About 74 percent of this assistance is for the purchase of equipment, while 25 percent is for R & D activity and one percent for market feasibility studies. Recent changes in the program will extend eligibility to companies that compete only in domestic markets and will put greater emphasis on repayment of grants out of returns from projects. However, DIPP funds compensate for only a fraction of the competitive disadvantage that Canada's lower level of defence spending imposes on Canadian firms relative to their U.S. competitors.

The major recipients of DIPP funding have been aerospace companies in Ontario and Quebec. The largest beneficiary has been Pratt & Whitney Canada, which received $333.2 million during the period 1969-1985 (See Exhibit VIII.21). Even though overall funding levels have increased, the Ontario industry's participation in DIPP has been declining; by 1985-86, Ontario received only 13.4 percent of DIPP benefits (See Exhibit VIII.22). Given

EXHIBIT VIII.21

DIPP FUNDING
1969-1985

Company	Location	Amount Received 1969–85 ($ Millions)
Pratt and Whitney Canada	Quebec & Ontario	$333.2
De Havilland Aircraft	Ontario	124.8
Canadair Limited	Quebec	123.1
Litton Systems Canada	Ontario	70.7
McDonnell Douglas Canada	Ontario	66.2
Bell Helicopter (Textron)	Quebec	56.6
Canadian Marconi/CMC Electric	Quebec	46.2
General Motors of Canada	Ontario	29.2
CAE Electronics Ltd.	Quebec	27.3
MICR Systems (Not aerospace)	Ontario	25.8
Spar Aerospace	Ontario & Quebec	25.4
Garrett Manufacturing	Ontario	14.6
Dowty Equipment of Canada	Ontario	12.4
DAF Indal	Ontario	11.5

Source: E Regehr, *Arms Canada*; 1987 Public Accounts of Canada.

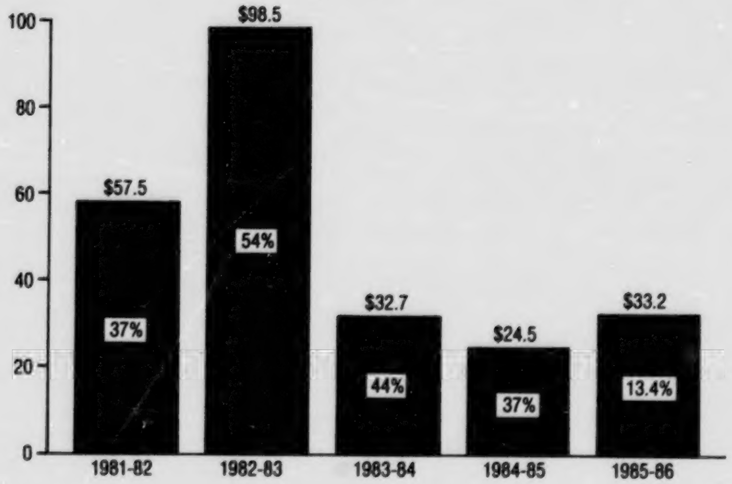
the current concentration of many aerospace firms in Ontario, this rapid decline in DIPP funding to Ontario appears to indicate the federal government's intention to redirect the aerospace industry away from Ontario. Indeed, the federal government has publicly stated its intention to make Montreal the centre for the fifth generation of the transport industry and to strengthen Montreal's role as an aerospace centre.

Provincial Policy

Given the federal government's current intentions, provincial policies will have to assume a larger role in enhancing industry

EXHIBIT VIII.22

ONTARIO PARTICIPATION AS A % OF TOTAL DIPP AUTHORIZED EXPENDITURES
1981-85
($ Millions)



Source: DIPP

capability and winning contracts. Provincial policies can actively seek to attract new aerospace industry, to assist smaller companies by risk-sharing on new products, to lobby for federal attention and fairness in funding, and to help meet industry infrastructure needs, especially in training.

Some participants in the aerospace industry believe that the Province of Ontario is not supporting the industry to the same extent that other provinces, particularly Quebec, are. Concern has also been expressed about the absence of expertise in the Ontario government with regard to the aerospace business. Finally, industry participants protest the lack of financial incentives provided by Ontario to encourage the establishment of aerospace businesses.

ISSUES FOR THE FUTURE

Consolidation and rationalization are taking place in the world aerospace industry. As a result, Canadian manufacturers, many of which are small by international standards, face a number of pressing issues. Increasing risks and narrowing margins on the international aerospace market, compounded in Canada by competitive disadvantages and skills shortages, pose difficult challenges to Canadian manufacturers.

Several global competitive trends are making export success more difficult for Canadian aerospace firms. These trends include greater local content requirements, worldwide rationalization of production, and increasing government subsidization.

Most governments are requiring greater local content in aerospace procurement contracts. Nearly all military and commercial aircraft sales now involve high levels of offset or technology transfer to the purchasing country. As these negotiations become more difficult and politically complex, the ability of manufacturers to deal with the requirements of foreign governments becomes an increasingly important factor in market success, as does cooperation with the government in the company's home country.

A second trend is worldwide rationalization of aerospace production. In military and large commercial aircraft manufacturing, only the largest competitors can survive as the costs and risks associated with introducing new aircraft continue to increase. Smaller companies must find ways to share these increased risks by forming international consortia for major projects.

Government subsidization is the third significant trend. Most of the major aerospace manufacturers outside Canada are government-owned and/or heavily subsidized by defence procurement and other government programs, usually to a much greater extent than Canadian firms.

The result of these three competitive trends has been consolidation of the world industry through mergers of aircraft makers and cooperative deals between engine makers. Recent mergers among aircraft makers include General Motors' purchase of Hughes Aircraft, Chrysler's purchase of Gulfstream Aerospace, General Dynamics' purchase of Cessna, and Boeing's purchase of De Havilland. Among the cooperative ventures have been the combination of General Electric and Rolls Royce in engines, the International Aero Engine project, which involves Pratt & Whitney, Rolls Royce, Japanese Aero Engines, MTU and Fiat, and the CFM International project with General Electric and Snecma cooperating.

Given these trends, the Canadian aerospace industry faces a number of pressing issues that may constrain its future growth. The four most serious issues for the aerospace industry are the constant high-risk investments required to compete internationally, its competitive disadvantages relative to U.S. competitors, the level of Canadian defence spending, and skills shortages in Canada.

High-risk investments are required in product R & D, start-up tooling, and production costs. In 1985 the Canadian aerospace industry spent $587 million, or 14 percent of sales, on new investments, mostly for R & D and new equipment. International competitiveness will continue to place significant demands on the industry's ability to find the resources necessary to finance future growth and new products.

A second set of issues relates to the competitive positions of the Canadian and U.S. aerospace industries. Relative to their U.S. competitors, Canadian aerospace firms have several disadvantages. Lower Canadian labour and engineering costs do not offset the competitive advantages of U.S. companies arising from higher levels of government assistance, major non-tariff barriers, a much larger domestic market, and a fully developed and vertically integrated industry.

U.S. government funding of defence and aerospace R & D poses a difficult competitive barrier to outside companies. The United States spends more on defence research and development and subsidizes a higher proportion of aerospace development costs than Canada does. Not only is total research and development spending in the U.S. aerospace industry 60 times that of Canadian aerospace R & D spending, but the U.S. government subsidizes 75 percent of that spending, compared to an average of only 50 percent by governments in Canada.

Finally, skills shortages, especially the lack of machinists, engineers, technicians, and project managers, have proved a recurring problem for Canadian aerospace manufacturers. For example, Ontario manufacturers of landing gear and other complex assemblies note skilled labour shortages as a serious and chronic problem. Of additional concern is the fact that businesses reporting shortages of skilled tradespeople are generally those in which value-added per employee is high and significant R & D is performed (See Exhibit VIII.23).

Two such firms, Devtek and Menasco, have identified a shortage of skilled machinists as a major issue, and although Menasco has grown from 350 to more than 500 employees in two years, skilled labour requirements have been difficult to fill. Both companies also noted that attracting European immigrants to fill skilled labour positions is no longer a feasible alternative. Training and retraining of a skilled Canadian labour force is therefore vital to these firms because of the technical nature of their manufacturing processes.

In a consolidating world aerospace industry in which Canada

EXHIBIT VIII.23

CANADIAN AEROSPACE VALUE-ADDED PER EMPLOYEE IN VARIOUS INDUSTRY SEGMENTS

Examples of Products	1986	Perform Significant R&D
Proprietary Airframe System	$82,000	Yes
Varied Electromechanical Assemblies	$52,700	Yes
Defence Avionics System	$52,500	Yes
Non-proprietary Airframe Structures	$41,000	Little
Non-proprietary Machined Component	$41,000	Little

Source: Telsis Interviews and analysis.

has several competitive disadvantages, it is imperative that governments adopt effective policy directions. Given the range of factors affecting competitive success and the number of industry segments, no one policy will be appropriate for every firm. Government must nevertheless endeavour to establish a mix of policy directions to address the four major constraints facing the Ontario aerospace industry: the shortage of highly skilled machinists and related tradespeople; growing protectionism in many international markets, leading to lost jobs and value-added in Canada as firms wishing to sell into those markets agree to offset and local content requirements; the need for Ontario's indigenous component firms to develop greater R & D capabilities so as to expand their market opportunities and secure more sustainable competitive positions; and the current federal tendency to concentrate its aerospace efforts outside Ontario by designating Montreal as the country's aerospace centre.

CHAPTER IX
COMPUTER HARDWARE

Computer hardware has been one of the most important new industries to develop over the last 30 years. At first, the growth of the computer hardware industry was driven primarily by the development of the technology: each new generation of hardware was capable of handling more processing more quickly and more cost effectively. But eventually the battle for competitive advantage shifted decisively to other fronts, such as marketing scale, service coverage, the level of installed product base, software availability, and not least importantly—manufacturing costs. Technological innovation can still be an important distinguishing factor in the marketplace, but long-term success has less to do with technical cleverness than it does with these other non-technical factors. IBM, for example, is rarely a technological leader in its market, but still retains a dominant position through other competitive means.

GLOBAL CONSOLIDATION

The computer industry is unusual in that it became a global industry at an early point in its evolution. As it evolved, the computer industry shifted from being a highly fragmented new industry, where competitive advantage depended primarily on technological innovations, to a market-driven, capital-intensive industry with a few very large players, which made new market entry, other than as a niche player, close to impossible. In the early years of computer hardware manufacturing, there were a number of Canadian entrants serving local markets, some with what appeared to be leading-edge technology. However, with the exception of a few survivors able to defend well-defined market niches, Canada is not a player in the international computer hardware industry today.

A major factor driving this rapid global consolidation has been the high cost of developing and distributing capital-intensive products for a market with product life cycles of sometimes less than two years. Customers, recognizing the high risks inherent in the computer business, tended to buy from well-established players who could be counted on for future service and related product development. This further reinforced the market position of leading suppliers.

Like other smaller countries, Canada had neither the private nor the public sector resources to stay in the race. Three Ontario universities—Queen's University, the University of Toronto and the University of Waterloo—have played a role in developing both people and technology that have since become part of the industry. However, without existing Canadian companies to absorb these resources, and in the absence of the substantial risk capital required to start new large-scale ventures, most of Canada's technological and human resources in the computer field have flowed to foreign-owned multinationals.

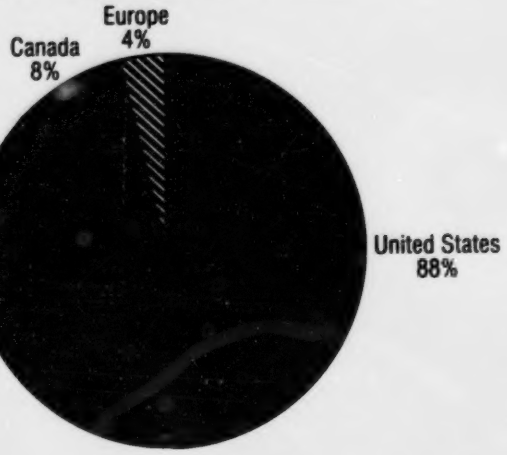
CANADA'S COMPUTER HARDWARE INDUSTRY

All of these factors have led to the creation of a $5 billion computer hardware industry in Canada today in which close to 90 percent of industry sales are accounted for by foreign-owned multinationals (See Exhibit IX.1). A few, such as IBM, Control Data, and Xerox, undertake significant R & D and manufacturing in Canada, principally in Ontario. Others have made token efforts to comply with pressure from the federal government during the 1970s to include more Canadian content in their products. Others simply import finished hardware for sale in the Canadian market.

EXHIBIT IX.1

1985 OWNERSHIP OF COMPUTER HARDWARE SUPPLIERS IN CANADA[1]

(Percentage of Industry Revenue)



[1] Includes firms that derive a major portion of their revenue from the sale or lease of their own manufactured hardware

Source: Evans Research.

EXHIBIT IX.2

COMPUTER HARDWARE SUPPLIERS IN CANADA

Foreign Owned Companies	EDP Sales 1985	Canadian-Owned Companies	EDP Sales 1985
	(Millions)		(Millions)
IBM Canada	$2,993	AES Data[2]	$143
Digital Equipment Corp.	470	Gandalf Technologies*	86
Control Data	278	GEAC Corporation*	65
Burroughs Memorex[1]	242	Comterm Ltd.	48
NCR Canada	211	Matrox Electronics	31
Sperry Inc.[1]	190	Electrohome*	26
Hewlett Packard	170	Develcon	24
Honeywell Inc.	153	Memotec	17
Amdahl	142	Northern Technologies*	14
Xerox Canada	119	Cybernex*	11
Total, Top Ten Companies	$4,968	Total, Top Ten Companies	$465

* Located in Ontario.

[1] Burroughs and Sperry merged in 1986 to form Unisys.

[2] AES Data is no longer Canadian-owned.

Source: Software News, May 1987.

The industry is heavily dominated by IBM; with sales of $3 billion, IBM accounts for 60 per cent of all Canadian computer hardware sales. The second largest supplier is Digital, with sales of $500 million. Taken together, the ten largest foreign-owned companies sell more than ten times the amount sold by the largest Canadian-owned companies (See Exhibit IX.2).

The largest Canadian-owned computer hardware manufacturer is Gandalf, which produces modems and other communications peripherals and has annual sales of less than $100 million. AES Data begins to approach the sales figures of some of the smaller multinationals, but it was sold to a U.S. based firm.

Like the Canadian industry generally, Ontario's computer hardware manufacturing industry boasts a high level of value-added. Reaching almost $70,000 per employee in 1983, value-added in computer hardware manufacturing is well above the Ontario industry average of just under $48,000 per employee in manufacturing. Value-added in computer hardware manufacturing in Ontario also compares favourably with that in other industrialized countries, including West Germany, Japan, and the United States.

However, Canada's trade deficit in computer hardware is among the highest in the industrialized world. Although exports have quadrupled since 1970, reaching almost $2 billion in 1985, the balance of trade in computer hardware has deteriorated precipitously, with the deficit soaring to $3 billion in 1985 (See Exhibit IX.3). Ontario's trade position in computer hardware is no different from the Canadian situation generally.

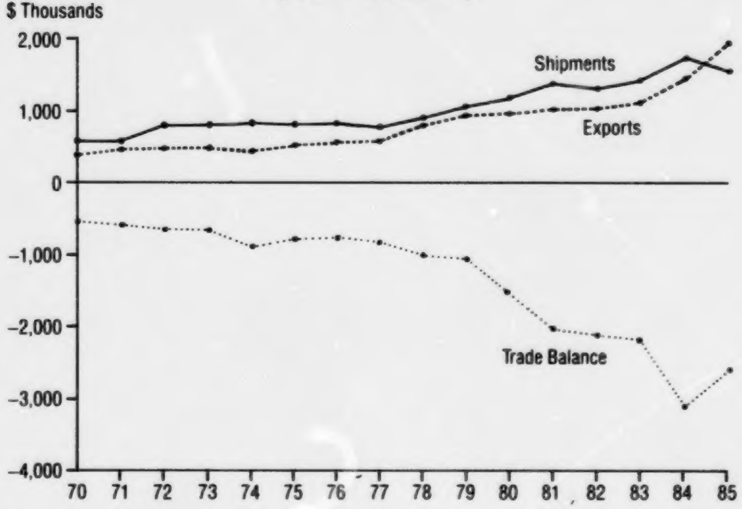
THE LIMITED ECONOMIC ROLE OF FOREIGN-OWNED MULTINATIONALS

Although the well-capitalized, large foreign manufacturers can supply the Canadian market with leading-edge computer hardware more effectively than small local firms can, Canada does pay a price for importing this technology instead of making it. The price is most apparent in the trade deficit. The science and engineering brain drain is another symptom; our best computer scientists are leaving Canada because challenging jobs are often not available in branch plants or in local firms of limited scope.

Just as serious in its economic consequences is the fact that multinational branch plants do not fill many of the roles generally played by indigenous firms. For example, they are rarely incubators of spin-off businesses. Although the most successful new businesses are often those spawned by established companies, the Premier's Council survey of start-up companies found

EXHIBIT IX.3

CANADA'S TRADE IN OFFICE MACHINERY: 1970-1985
(Real 1985 Dollars)



Source: Statistics Canada

nies, the Premier's Council survey of start-up companies found that very few Ontario new businesses came into being as a result of the presence of foreign-owned multinationals.

Because most multinational enterprise branches operating in Canada are not fully integrated companies, they do not generate networks as readily as indigenous firms do. For example, eight of the ten largest foreign-owned computer hardware manufacturers do some manufacturing and R & D in Canada, but only in one case (Control Data) are these two functions integrated with research and development in Canada leading directly to product manufacturing in Canada (See Exhibit IX.4).

Most branches of multinationals operate under world product mandates—a contract with their head office to research a particular problem or manufacture a particular component. For the multinationals, this is an effective strategy because it fosters healthy competition among its branches to control costs and improve quality in order to win contracts for world product mandates. It also allows each plant to produce at world scale for a specialized item, instead of duplicating facilities throughout the world to serve local markets.

EXHIBIT IX.4

MANUFACTURING AND R&D ACTIVITY OF FOREIGN OWNED MULTINATIONALS IN CANADA

Company	1985 Canadian Sales ($ Millions)	Computer Hardware Manufactured in Canada	Percentage of Manufacturing in Ontario	Computer R&D in Canada	Integrated R&D in Canada[1]
IBM Canada[1]	$2,993	Printers, display terminals, supplies, electronic cards, semiconductor substrates	50%	Yes	No
Digital Equipment*	470	Interconnect products VAX-11/780	100%	Yes	No
Control Data*	278	CYBER Computers Defence systems	100%	Yes	Yes
Burroughs Memorex**	242	Disk drives, consumables, printing	<50%	Yes	No
NCR Canada*	211	Banking system, point of sales terminals	100%	No	No
Sperry Inc.**	190	Re-manufacturing of disk storage devices	0%	Yes	No
Hewlett Packard	170	None (Planning to begin manufacturing over the next five years)			
Honeywell Inc.*	153	None	—	Yes	No
Amdahl	142	Communications equipment	100%	No	No
Xerox Canada	119	Copier document feeder, toner	100%	Yes	No

*These companies are "fully rationalized" under federal government Canadian content guidelines.

**The corporate re organization of Unisys has shifted the ratio. Memorex, with Montreal operations, is being sold and the Sperry Winnipeg plant is going to be given a world product mandate.

[1] Means R & D is integrated with manufacturing such that the R & D work is for products made in Canada.

Source: Company Annual Reports and Canada Consulting interviews.

Multinational branch plants play a more limited economic role in the Canadian industry than indigenous firms because they tend to focus on sales and marketing in the Canadian market rather than on R & D or on manufacturing a full range of products for the Canadian market. If world-scale manufacturing does take place in a Canadian branch plant, the operation usually reports to and is integrated with the operations of the parent company outside Canada. R & D expenditures and export sales generally account for a higher percentage of sales in Canadian-owned firms than in foreign-owned enterprises. Interviews conducted for the Council indicate that exports from Canada by U.S.-owned firms average some 22 percent of sales, compared with 35 percent for Canadian-owned firms. Similarly, R & D by Canadian-owned firms averages ten percent of sales, compared to three percent for U.S.-owned companies.

IBM Canada stands out as an exception to these observations about the economic role of multinationals operating in Canada. Canada has a unique historical relationship with IBM. In 1911, Canada became their first foreign location. In fact, International Business Machines was originally the name of the Canadian subsidiary before it was adopted by the whole company. IBM has carried out R & D and manufacturing in Canada under world product mandates since the 1960s. In 1985, close to $1 billion in manufactured products was exported back to the United States from IBM plants in Toronto and Bromont, Quebec. In the same year, software valued at $100 million was developed in IBM's Toronto R & D laboratories, which employ more than 1,000 researchers.

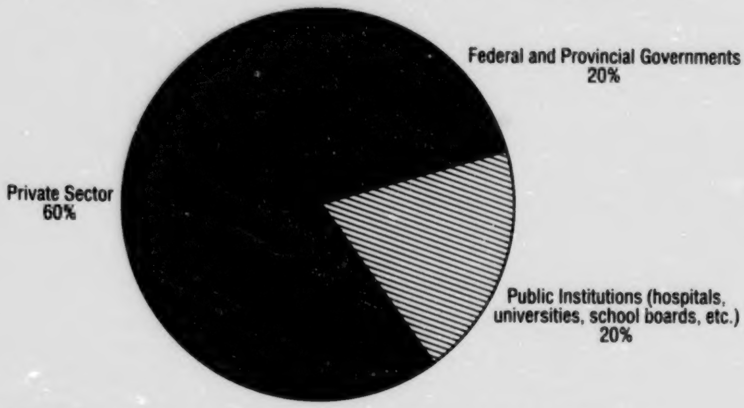
THE CRITICAL ROLE OF GOVERNMENT PROCUREMENT

Given the current situation in the industry, government procurement is an important mechanism for influencing the growth of the computer hardware industry to serve Canada's economic and industrial development purposes. Public sector purchases, primarily for government departments and laboratories and for universities, make up 40 percent of the Canadian computer market (See Exhibit IX.5).

In the past, the federal government made some attempt to influence industrial development by requiring foreign-owned companies to have a certain ratio of exports to imports in order to be considered preferred suppliers. This system is being replaced, however, by a case-by-case approach to procurement from multinational enterprises. The current federal government, eager to foster the establishment of large multinationals in Canada, has traded away procurement policies favouring Canadian firms and replaced them with policies serving large low-cost suppliers with

EXHIBIT IX.5

THE CANADIAN MARKET FOR COMPUTER HARDWARE



Source: Based on public and private sector interviews and data compiled by The Canada Consulting Group, 1987.

"some Canadian presence". In interviews, key public servants responsible for economic development in the computer industry could not even name any Canadian-owned manufacturers. But they had just returned from a trip to the United States aimed at encouraging other multinationals without a presence here to open branches in Canada under new, more relaxed government procurement policies.

According to federal government officials, fostering of development in the indigenous computer industry is expected to happen as a secondary result of the increased presence of the multinationals in Canada. Policies are under consideration to encourage the development of Canadian suppliers for these original equipment manufacturers (OEMs). For example, a certain portion of a government contract awarded to a multinational enterprise might have to be subcontracted to Canadian-owned companies.

Several indigenous hardware manufacturers interviewed were cynical about the value of this approach. Their experience in trying to sell into other countries, on the "fair" basis on which foreign companies are allowed to sell into Canada, has been met again and again by protectionist policies favouring local firms. In their view, entering into contracts with OEMs and becoming dedicated suppliers to foreign-owned multinationals is a limiting strategy for them. They lose touch with the end users of their products and become simply production lines dependent on the fortunes and acumen of another company. Product development and marketing activities are minimal in companies competing on price for contracts with OEMs. A national strategy creating a computer hardware industry of subcontractors to multinationals is virtually no strategy at all.

In Ontario, as at the federal level, procurement policies are not effectively related to industrial development objectives. Like its federal counterpart, the Ontario government usually selects the "lowest-priced technically compliant bid", but Ontario adds a ten percent price premium to bids lacking Canadian content. It also tends to make small purchases. For example, in 1985-86, there were 4,000 separate computer hardware procurements with a total value of $183 million. Small-scale contracts spread among hundreds of suppliers clearly do not promote the creation of a few world-scale firms. Large contracts requiring challenging new product development work would foster consolidation and growth of the industry.

At present, however, the objective of purchasing reliable systems at the lowest possible cost takes precedence over the achievement of economic or industrial development objectives that could be pursued through the procurement policies of both federal and provincial governments.

THE COMPETITIVE DILEMMA FACING CANADIAN FIRMS

Canadian firms competing in an international market dominated by foreign multinationals face at least four dilemmas that constrain their growth. First, Canadian hardware manufacturers are "niche" players serving specialized markets with products that the large vendors often cannot supply as cost-effectively (See Exhibit IX.6). Because of their small size, they have had to focus on specific product or market niches and aim for competitive scale within those niches. However, if a niche grows, larger firms do enter, often acquiring the niche company or putting it out of business. If the niche does not expand, the company must look for new product or market niches in order to grow. For a small, undiversified firm, this usually means betting the company on every new product it launches.

The second dilemma facing small Canadian firms is that each new generation of computer hardware costs more to develop than the last, to the point where a company cannot bear the costs of failure. Yet not investing in new product development spells certain failure.

For example, in the early 1970s, GEAC, a $70 million Canadian

EXHIBIT IX.6

EXAMPLES OF PRODUCT NICHES OF CANADIAN SUPPLIERS

	Product Niche
Gandalf	Modems
GEAC	Library Automation Systems Small Banking Systems
Meridian	Microcomputer Hardware and Software for Schools
Lanpar	Connector Covers to Filter Noise and Radiation
Dipix	Image Processing and Analysis Equipment for Remote Sensing

Source: Company interviews for the Premier's Council, 1987

computer company, developed proprietary hardware for large data base/terminal transaction data processing. They targeted two specific markets: library automation and small financial service businesses, especially credit unions. By 1983, it was clear that the Canadian market would not be able to continue to support the company's growth. GEAC identified U.S. banks as its next market and, for the next four years, spent more than $30 million on product development (See Exhibit IX.7). The resulting Advanced Banking System product was one year late and $5 million over budget. It also failed in its first installation. In a large company, problems on this scale would be common and almost expected. GEAC, however, already financially precarious, was almost pushed into bankruptcy. Subsequent financing and other assistance are giving the company an opportunity to recover, but it may have to continue as a software and systems house, not as a hardware manufacturer.

A marketing dilemma also faces many small firms in the hardware industry. Selling to original equipment manufacturers can circumvent the problem of insufficient marketing scale, but once a company is locked into a dedicated supplier relationship it usually loses touch with the end users of its products and must rely on the OEM for product development direction. On balance, selling to OEMs may "jump-start" a small firm, but a continuing and exclusive relationship with an OEM can inhibit the long-term growth and profitability of the smaller firm.

EXHIBIT IX.7

	HISTORY OF GEAC PRODUCT AND MARKET DEVELOPMENT
1971	GEAC established as a systems and applications software company
1976	GEAC began proprietary hardware development specifically for large data base and terminal population transaction processing
1977	Installed their first complete Canadian financial system
1978	Installed their first complete library automation system
1977-86	Hundreds of financial system customers in Canada
	130 library system customers (15% of the world market)
1983-86	Development of new Advanced Banking System product for the U.S. market —one year late, $5 million over budget, and it failed in its first installation
1986-87	A combination of factors threatens the future of the company, and GEAC is moving out of manufacturing and returning to being a software company compatible with generic hardware

Source: Canada Consulting Group Inc. and Telesis interviews, 1987.

Finally, the government procurement dilemma aggravates the problems created by too much dependency on an OEM. Government procurement policies that require OEMs to have Canadian suppliers as subcontractors may encourage Canadian-owned companies to enter into these relationships. However, apart from these occasional subcontractor requirements, there are no policies or practices favouring Canadian-owned computer hardware manufacturers in government purchasing decisions.

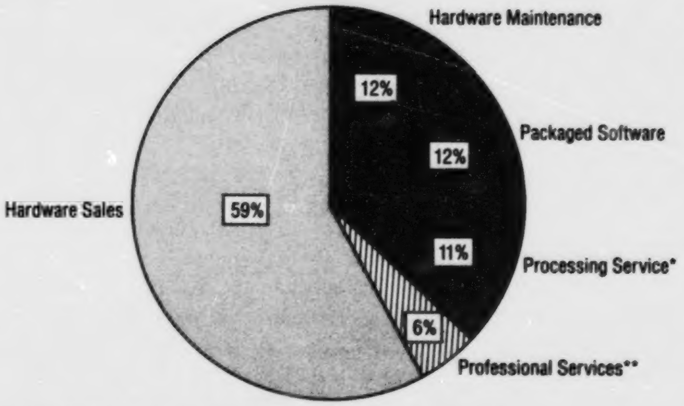
Given the dilemmas facing Canadian-owned computer hardware manufacturers, coupled with the expectation that hardware sales will fall as a percentage of total industry revenues by the 1990s, the best hope for Ontario companies in the computer industry may well lie in sales of software and systems integration services. That sector, as discussed in the next chapter, poses its own competitive challenges.

CHAPTER X
COMPUTER SOFTWARE AND SERVICES

Computer software and services, once considered merely adjuncts of a computer industry primarily concerned with hardware manufacturing, have become the fastest growing segments of the market (See Exhibits X.1 and X.2). Software and services have become an entirely separate industry, with competitive dynamics very different from equipment manufacturing. Unlike the highly consolidated computer hardware industry, software and services are part of a very diversified, and in some cases fragmented industry, with opportunities for gaining world scale in specialized niche markets. Sales of computer software and services are growing more quickly than sales of hardware and in 1986 accounted for 41 percent of computer industry revenues. By 1990 in fact, hardware sales are expected to decline to 52 percent of total industry revenues (down from 63 percent in 1983), while sales of packaged software will rise to 22 percent of total revenues (up from seven percent in 1983). Packaged software sales

EXHIBIT X.1

CANADIAN COMPUTER INDUSTRY
1986 Revenues



* Includes batch processing, remote problem solving, remote automated transactions.
**Includes contract programming, facilities management, data processing consulting.
Source: International Data Corporation, 1987 Reports.

EXHIBIT X.2

COMPUTER INDUSTRY GROWTH BY SEGMENT, 1983-86
($ Millions)

	1983 Revenue	1986 Revenue	1983-86 Compound Growth Rate
Hardware—sales, lease, rental	$3,756	$4,685	8%
Hardware Maintenance	825	988	6%
Packaged Software	431	963	31%
Processing Services	668	873	9%
Professional Services	272	449	18%
Total Revenues	$5,952	$7,958	10%

Source: International Data Corporation, 1987 Reports.

are experiencing the highest compound growth rate in the industry, followed by sales of professional computer services.

At the same time, Canada has a significant and rapidly growing trade deficit in computer software, estimated to be in the range of $2 billion to $3 billion and growing by 20 to 30 percent annually. However, Canadian ownership of companies in the electronic data processing market is four times higher than ownership in the hardware industry. Moreover, there is a wide range of export and value-added potential in the specific product segments where Canadian-owned firms have strong positions (See Exhibit X.3). For these reasons, Canada's best hope in the computer industry lies in the software and service segments, where Canadian-owned firms can still become world players.

INDUSTRY STRUCTURE

The software and service industry is made up of four broad markets: packaged software, professional services (custom software design and systems integration), processing services (service bureaus, large-scale transaction processing), and data bases. These markets are made up of many unique competitive segments, each with its own dynamic and each requiring a different set of skills and resources for success (See Exhibit X.3).

EXHIBIT X.3

COMPETITIVE DYNAMICS OF THE SOFTWARE & COMPUTER SERVICE SECTORS

Market Segment	Market Structure	Canadian Industry Structure	Basis For Competitive Advantage
Software Packages	• Direct selling to end user in high end • Value-added resellers in middle-high end • Mass market retail outlets at low end • Distributors at low end have market power	• Dominated by foreign firms • Only one Canadian company of scale	• Marketing and distribution scale • R&D scale • Product differentiation
Professional Services	• Direct selling • Consortium activity growing	• Many small companies • Highly fragmented at low end • High degree of Canadian ownership	• Product differentiation • Market specialization • Purchasing scale in hardware reselling segments
Service Bureaus	• Direct selling • Close customer relationships including cross-ownership • Regional markets	• Few established firms dominate each market • High Canadian ownership • Significant government ownership	• Processing optimization • Industry-specific knowledge • Related diversification that obtains economies of scope
Data Bases	• Direct selling • Direct mail and advertising	• Concentrated • Few players in each segment	• Proprietary product • Cost of duplicating data base

Source: The Canadian Consulting Group Inc. and Telesis interviews and analysis

EXHIBIT X.4

CANADIAN SOFTWARE AND SERVICE COMPANIES BY MARKET SEGMENT

Market Segment	Total No. of Companies in Canada	Examples		1985 Est. Software & Service Sales ($ Millions)	Ownership	Degree of Specialization
		Company	Products			
Software Packages[1]	200	IBM	Foreign language word processing	$299	U.S.	Diversified
		Digital	Minicomputer software	$120	U.S.	Diversified
		Honeywell	Process control	$75	U.S.	Diversified
		Cognos	4th generation language	$45	Cdn.	Niches
		Batteries Included	Productivity software	$14	Cdn.	Niches
		Sydney Developments	Vertical market applications software	$13	Cdn.	Niches
		Cableshare	Accounting software	$11	Cdn.	Niche
		Alias	Colour graphics software	$8	Cdn.	Niche
		Develcon	Manufacturing software	$8	Cdn.	Niches
		Corel Systems	Desktop publishing	$7	Cdn.	Niche
		Dipix	Satellite imagery systems	$5	Cdn.	Niche

[1] Does not include companies which are sales operations only.

Source: Annual Reports and interviews by Canada Consulting Group Inc.

EXHIBIT X.4 (Continued)

Market Segment	Total No. of Companies in Canada	Examples		1985 Est. Software & Service Sales ($ Millions)	Ownership	Degree of Specialization
		Company	Products			
Service Bureaus	100	Crowntek	Shared processing	$168	Cdn.	Diversified
		CSG	Canada Savings Bonds processing	$140	Cdn.	Niches
		1st Inc.	Shared processing	$41	Cdn.	Diversified
		Cooperators	Shared processing	$23	Cdn.	Diversified
		ADP	Securities processing	$23	U.S.	Niches
		Saskatchewan Computer Utility	Shared computing	$22	Cdn.	Diversified
		Comcheq Service	Payroll services	$10	Cdn.	Niche
Data Bases	30	CSG	Financial data bases	$140	Cdn.	Niches
		IP Sharp	Aviation and other data bases	$53	Cdn.	Niches
		ADP	Stock and commodity information	$23	U.S.	Niches
		Dataline	Oil and gas data bases	$21	Cdn.	Niches

Packaged software is the most traded sector of the market and one where a high percentage of value-added from sales in export markets returns to Canada. The professional services and data sectors are also traded, but service industries require a higher level of local participation, reducing the value-added to Canada of sales in export markets. Processing services, the most mature sector, is traditionally a domestic industry serving local markets, although leading firms today are seeking opportunities to diversify.

Players in the software market in Canada include foreign-owned hardware manufacturers (such as IBM), a few Canadian hardware manufacturers (such as GEAC), large foreign-owned software and service vendors (such as Lotus and ADP), and Canadian-owned software and service vendors (such as Cognos and Systemhouse) (See Exhibit X.4). Multinational computer hardware companies are also the world's largest software vendors, but the concentration of the market is not nearly as overwhelming as in hardware (See Exhibit X.5).

EXHIBIT X.5

1986 REVENUE OF WORLD'S LARGEST SOFTWARE COMPANIES

Company	Software Revenue ($ Millions)	Total Revenue	Software as a % of Total Revenue
1. IBM	$5,514	$49,591	11%
2. Unisys	861	9,431	9%
3. Digital	560	8,414	7%
4. NEC	507	6,325	8%
5. Fujitsu	389	6,576	6%
6. Siemens	387	4,387	9%
7. Hewlett Packard	375	4,500	8%
8. Hitachi	331	4,729	7%
9. Nixdorf	300	2,075	14%
10. Lotus Dev.	283	283	100%
11. Microsoft	260	260	100%

Source: Datamation, June 15, 1987.

Together, the hardware manufacturers comprise one-third of the world software and service market and, with the exception of IBM, their software revenues are within the range of the largest independent software vendors (See Exhibit X.6). In Canada, IBM is the largest software and service supplier, with 1985 revenues of $300 million. This is approximately twice the size of rivals Control Data and Digital Equipment. Canadian-owned firms, which make up 26 percent of the Canadian market, are the largest

EXHIBIT X.6

TOP INDEPENDENT SOFTWARE VENDORS 1986

	Worldwide Revenue ($M)	U.S.-Only Revenue ($M)
1. Lotus Development	$282.9	$212.9
2. Microsoft	260.0	195.0
3. Computer Associates International	246.9	150.0
4. Ashton-Tate	203.1	163.0
5. Dun & Bradstreet Corp.	200.0	128.7
6. MSA	186.7	132.7
7. Software AG	180.0	80.0
8. Cullinet	166.9	138.4
9. Uccel	141.5	Not Available
10. Applied Data Research	132.4	76.4
11. Sterling Software, Inc.	113.4	112.0
12. McDonnell Douglas Info. Sys.	112.3	93.9
13. Cincom	102.7	51.3
14. SAS	102.4	Not Available
15. Pansophic Systems Inc.	98.0	69.0
16. Information Builders	94.0	74.0
17. Oracle	88.0	52.8
18. Candle Corp.	76.0	Not Available
19. AGS Computers	55.0	22.0
20. Wordperfect Corp.	52.2	47.2
21. Autodesk	50.3	34.3
22. Cognos*	47.1	25.5
23. Advanced Systems Applications	46.0	46.0
24. American Management Systems	44.1	44.1
25. Compuware	43.6	30.8

*Canada's largest packaged software company.
Source: *Software News*, May 1987.

EXHIBIT X.7

EXAMPLES OF SUCCESSFUL PRODUCT AND MARKET NICHES

Company Product & Market	Product Sales	Market Share	Market Share of Largest Competitor
4th generation language software development tools	$45.3 million	33%	27%
Sophisticated graphics design software for video production	$8 million	25%	19%
Program development tools that increase productivity for university and high school computer science students	$3.7 million	30%	10%
Information retrieval software for electronic publishing and office automation OEM's	$3 million	50%	20%

Source: Premier's Council Interviews and Canada Consulting analysis, 1987.

vendors in Canada in some specialized sectors. As in computer hardware, the most successful companies have focussed on well defined niches and acquired a high market share (See Exhibit X.7).

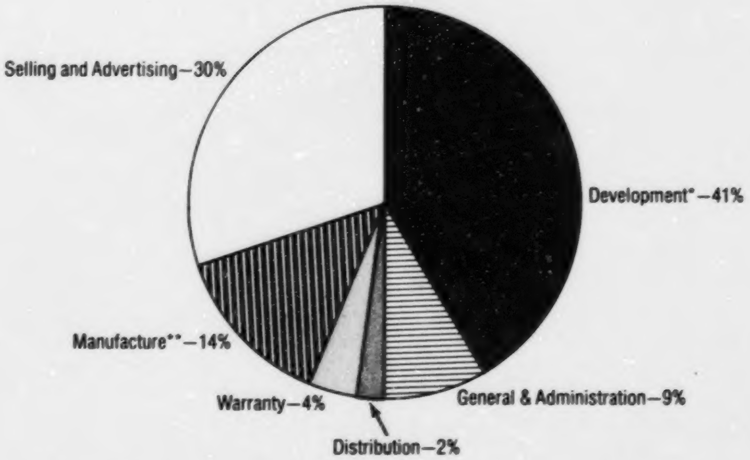
Packaged Software

Packaged software is the fastest growing segment of the software and services market. Competitive advantages in packaged software typically stem from marketing and R & D scale, product differentiation, and superior access to distribution channels. In fact, in the case of a personal computer software package, costs for marketing are almost as high as development costs (See Exhibit X.8).

The largest independent packaged software firms in the United States have achieved world sales approaching $300 million (U.S.). However, there are many market segments where the dominant player has sales in the range of $50 million. For exam-

EXHIBIT X.8

TYPICAL COST STRUCTURE
Personal Computer Software Package
1987



* Development includes quality assurance, manual writing, and management time allocation.
**Manufacturing includes copying diskettes, manuals, and packaging.
Source: Company interviews by Canada Consulting and Telesis.

ple, in Canada, Cognos stands out as the one packaged software firm that has achieved that level of sales in a specialized niche throughout the world.

Cognos began as a custom software and systems company, relying to a great extent on government procurement contracts. In the early 1980s, they developed an outstanding fourth-generation language system for the Hewlett Packard mini-computer. The company made a strategic decision to get out of the computer services business completely and to concentrate their resources on penetrating this specialized market with their new "Powerhouse" software product. Today, they have a 70 percent world market share in fourth-generation language software on HP equipment and are diversifying to Digital and Data General computers.

Cognos believes that a major reason for their success was that they began by creating software for a hardware company with a relatively small installed base and dominated that market first, instead of trying to take a small share of the IBM or DEC language systems markets. Today, Cognos ranks number 22 on the list of the world's largest independent software companies and exports 80 percent of its product. Its cumulative R & D investment since 1980 exceeds $30 million.

Many other Canadian packaged software companies are still in the range of $5 million to $15 million in sales. Some, such as Fulcrum in Ottawa, have achieved success with a single product in a specialized niche (in this case, library information retrieval systems). However, small independent firms often have difficulty obtaining financing for the development of their subsequent product generations. Success in software product development is driven primarily by the time it takes software writers to produce a new product. If development cycles are slow because a firm has a small, under-equipped R & D staff, the firm may lose out to larger competitors in an industry characterized by short product life cycles. Interviews with Ontario firms showed that their software development costs ranged from $100,000 to $10 million, and that products typically took one to three years to develop and had a sales life of two to six years.

The experience of these firms in the packaged software market shows the importance of selecting a niche carefully and gaining a strong foothold before moving to conquer another target. Gaining a high market share in a worldwide niche enables a company to gain competitive advantages by amortizing R & D costs over a larger number of units, investing larger amounts in marketing and after-sales services, and gaining future sales advantages through repeat business and add-ons to their original products.

Systems Integration

Systems integration is the fastest growing part of the professional services sector. In this industry, Canada has two large firms with sales over $50 million: DMR, a Quebec-based company, and Ontario's Systemhouse. In contrast to the packaged software sector, success in systems integration depends less on overall market share and more on cumulative experience in addressing systems requirements for a specific situation.

The growth of both DMR and Systemhouse has been due largely to federal and provincial government procurement contracts. The major cost component in systems integration projects is labour, and a firm experienced in a particular type of installation can gain significant cost advantages over their competition in subsequent contracts (See Exhibit X.9).

Firms such as Systemhouse have used federal government procurement contracts to move themselves down the experience curve and then have capitalized successfully on that experience by selling similar installations in domestic and foreign markets. However, Systemhouse is very small compared to the large U.S. firms and holds only one percent of the overall North American market (See Exhibit X.10). In particular, two giant U.S. firms, EDS and Computer Science Corporation, are increasing their presence in the Canadian market, partially through winning federal procurement contracts for government computer systems.

Processing Services

Growth in the processing services market segment has slowed considerably in the last decade. Increasingly, powerful equipment is becoming more affordable to end users, making shared processing a less attractive alternative. The Canadian market is dominated by two indigenous companies, Crowntek and Canada Systems Group. Both are seeking ways of increasing the value-added in their products beyond the value of simple transaction processing.

Data Bases

One source of diversification for processing services firms is the fourth segment of the software and services market, data bases. This is the smallest segment of the market and is dominated by a few major players, including Canadians, Canada Systems Group and I.P. Sharp—both Canadian companies.

GOVERNMENT PROCUREMENT

As with computer hardware, government procurement contracts can be an important tool in fostering the growth of Cana-

EXHIBIT X.9

GAINING COMPETITIVE ADVANTAGE IN SYSTEMS INTEGRATION WORK

COST STRUCTURE OF A TYPICAL SYSTEMS INTEGRATION PROJECT		COST LEVERAGE AVAILABLE
Purchased hardware and software	50%	Minor cost leverage from purchasing scale
Salaried direct labour	30%	Major cost leverage from previous experience
Sales and Marketing	5%	
Overhead	4%	Minor cost leverage from regional scale
Profit	11%	
Total	100%	

Source: Canada Consulting Group Inc. and Telesis interviews and analysis, 1987.

EXHIBIT X.10

U.S. SYSTEMS INTEGRATION VENDORS
Estimated Market Share in U.S.
1986

EDS (U.S.)	52%
Computer Science Corporation (U.S.)	12%
Systems Development Corporation (U.S.)	10%
Planning Research Corporation (U.S.)	5%
Systemhouse (Canadian)	1%

Source: Computerworld, November 1986

dian software firms. It has been used with some success by the federal government, although purchasing still tends to favour well-established U.S. software packages.

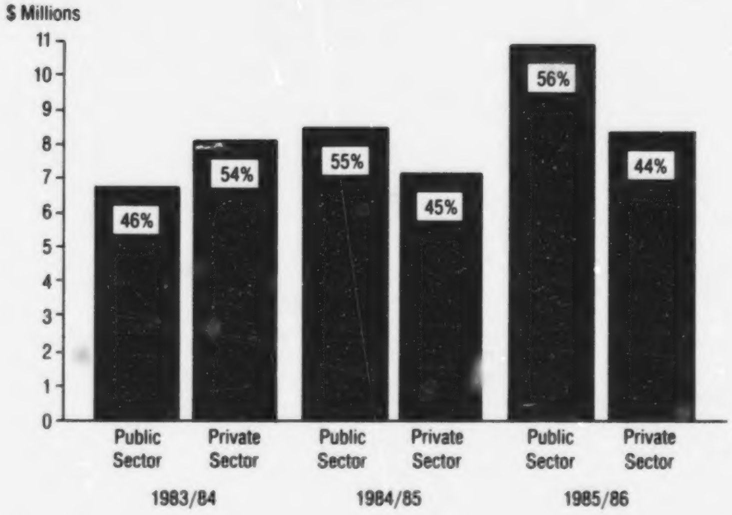
Ontario government procurement policies emphasize internal control of information systems, increasing the use of inside staff (rather than outside consultants), and spreading external contracts among many small suppliers (See Exhibit X.11). Each of these tendencies has worked to inhibit the emergence of an internationally competitive Ontario software industry. The average computer software and service contract for the Ontario government is in the $20,000 to $50,000 range. This approach has created an Ontario software industry made up of many small firms selling their services on a per diem basis. Without large, challenging contracts, there is no demand for the industry to consolidate and gain the economies of scale needed to make Ontario companies competitive internationally.

In contrast, the Quebec government has purposely used procurement to create a private sector computer services industry that will grow beyond the borders of Quebec. Large provincial government contracts give these firms substantial experience in designing major systems, helping them develop a competitive edge in the private sector market. As a senior executive of DMR put it: "DMR is a product of the buy against build policy of [the government of] Quebec." Systemhouse, by contrast, has grown in spite of Ontario's policies—oftentimes aided by contracts from other provincial governments and the federal government.

Effective and sustained development of the software industry in Ontario could be greatly aided by a new approach to procure-

EXHIBIT X.11

ONTARIO GOVERNMENT SYSTEMS DEVELOPMENT EXPENDITURES



Source: Report of Management Board of Cabinet, 1986.

ment. Unlike the situation in computer hardware, Ontario could still emerge as a major software developer and exporter.

CHAPTER XI
THE CASE OF LASERS

The laser industry is one emerging sector where Ontario enjoys a strong competitive position and has created a good environment for high technology start-ups. In Lumonics, of Kanata, Ontario has one of the world's leading laser companies, and five smaller companies broaden Ontario's base in the laser industry. As in many emerging industries, however, the competitive priorities for success in lasers are shifting. In the industry's infant stage, competitive success depended primarily on inventive research and the development of a technological lead, but as the industry has developed, other factors, such as economies of scale in manufacturing and distribution, have become increasingly important. An industry shakeout is now taking place, and despite the strong technical and market position of Lumonics, the company's success and even its survival are by no means assured.

Four aspects of the laser industry are discussed in this chapter. We begin with an overview of the world industry, followed by a more focussed look at the Ontario industry. Because Lumonics is Ontario's best hope in lasers, we examine the competitive challenges facing this threshold company, which is confronting larger competitors during a period of upheaval and realignment in the industry. The chapter concludes with a discussion of several issues identified by companies in the laser industry during the course of the Council's research.

THE WORLD INDUSTRY

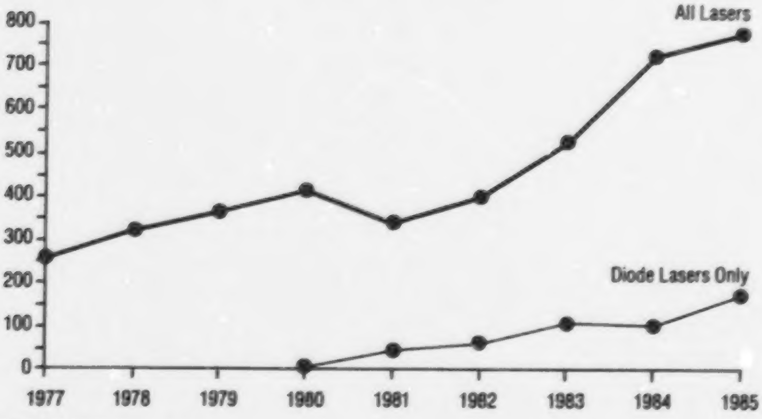
The world laser industry is currently experiencing dynamic change and remarkable growth. The sales volume of the world laser market doubled between 1980 and 1985, reaching $785 million (See Exhibit XI.1). Concurrent with this growth, the industry is witnessing two major shifts. First, the variety of technologies and the number of applications for lasers are rapidly expanding. There are now many applications for laser technologies and many product segments, each with different competitive factors and growth rates. At the same time as the industry is diversifying in terms of the number of market needs it serves, players within the industry are consolidating their positions. As competitive factors in many segments shift away from technological leadership and toward scale in production and marketing, companies are forming alliances (often with non-laser firms) and industry leaders in each segment are clearly emerging. Japanese laser companies threaten to accelerate this rationalization process with the introduction of new semi-conductor diode lasers and competitive advances into North American industrial laser markets.

In very general terms, the laser industry can be divided into low-cost diode lasers and more expensive gas, liquid, and solid state lasers. During the 1970s gas, liquid, and solid state lasers were the first to be introduced to world markets, and by 1986 they still accounted for 79 per cent of the world market. North America dominates in the manufacture of these laser technologies, which are used in materials processing, scientific applications, medicine, and laser printers. The less expensive diode lasers, which were introduced to the world market in 1980, represent 21 percent of the market and are rapidly gaining share. Diode lasers have applications in compact disk players, telecommunications, and laser printers. The Japanese dominate this lower end of the market.

A second way of dividing the laser industry is to consider the types of uses to which lasers are put. A wide range of laser technologies exists, each suited to different applications (See Exhibit XI.2). The largest selling technology, holding 25 percent of the

EXHIBIT XI.1

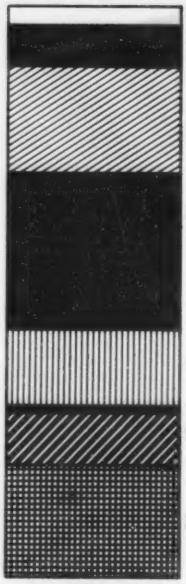
WORLD LASER MARKET
1977–1985
(Cdn. $ Millions)



Source: Laser Focus.

EXHIBIT XI.2

LASER TECHNOLOGY SEGMENTS
World Market Shares By Types of Laser



1986 Market Share	*Type of Laser*	*Applications*
3%	Excimer - Gas	Scientific, cutting, marking
6%	Dye - Liquid	Scientific
20%	CO2 - Gas	Marking, cutting & welding, medical, scientific
25%	*Solid State* Nd: YAG Glass Ruby Other	Cutting & welding, military, scientific, medical
15%	ION	Medical, scientific, printing
1%	He-Cd - Gas	Scientific, printing, optical memories
9%	He-Ne - Gas	Printing, test & measurement, bar coding, scientific
21%	Diode	Optical memory, telecommunications

Cdn. $ 785 Million

Source: Laser Focus and Telesis interviews.

market in 1986, was solid state lasers, which are used for cutting and welding, military, scientific, and medical applications. The technologies involved in lasers, as well as their applications, have multiplied over time and are expected to continue to do so. Although it is a complex and diverse industry, seven major laser applications account for 91 percent of all laser sales. The most common uses of lasers are in materials processing and scientific work, which together accounted for 41 percent of all lasers sold in 1986. Several types of lasers may find uses in a given field; for example, solid state, ION, and excimer lasers are all used for scientific work, while ION, CO_2, solid state, and excimer lasers all have medical applications (See Exhibit XI.3).

Consistent with the notion that the combination of laser types and laser applications creates a multitude of distinct businesses,

EXHIBIT XI.3

LASER APPLICATION SEGMENTS

	1986 Market Share	Unit Price*	Type of Laser
Materials Processing (cutting, welding & marking)	21%	$10,000-100,000	CO2, solid state
Scientific	20%	Entire Range	Solid state, ion, excimer
Medical	14%	$1,000-10,000	Ion, CO2, solid state, excimer
Optical Memories	13%	$5-50	Diode
Military	12%	Entire Range	Solid state
Telecommunications	6%	$100-3,000	Diode
Laser Printing	5%	$50-100	He-Ne, ion, diode
Other	9%	—	
Total	100%		

*Laser only.

Source: Telesis interviews and analysis.

competitive factors and growth rates differ significantly among product segments. The competitive factors in each segment are determined, for the most part, by the type of customer in that segment. For military applications, technical considerations are paramount while cost considerations are not. In most medical laser segments, large, well-defined marketing, sales, and support organizations are critical (See Exhibit XI.4).

Even as the technologies involved in lasers and the number of businesses in the laser industry are multiplying each year, the laser industry as a whole is consolidating and rationalizing as the basis for competition changes. While early competitors could succeed on the strength of technical capability alone, scale in marketing and production, service coverage, product reputation, and other factors are now becoming more important to success. Standard laser applications are now required in many major markets, making economies of scale in applications engineering a critical competitive factor. Repeat installations of a given laser can drive a company's costs down quickly, causing a scale-driven shakeout in the industry.

Economies of scale in marketing also become increasingly important as large, specialized markets, such as opthalmic applications, requiring dedicated sales forces, have evolved. The size of a company's installed laser base has also become a competitive advantage in industrial markets, which tend to be conservative and favour those firms with established records. Repeat sales in such markets also tend to be very important and, of course, favour established firms.

Aggressive competitive threats from Japan have also increased pressures to consolidate. Japanese competition threatens to accelerate the rationalization process with semiconductor diodes, which may replace traditional lasers in many applications at the low end of the market. The threat of Japanese entry into the North American market for industrial lasers has already forced a restructuring in those segments as companies look for alliances with manufacturing technology firms. The result of these changes in the competitive dynamics of the laser industry is that hundreds of firms currently in existence are consolidating among themselves and forming alliances with non-laser companies.

THE ONTARIO LASER INDUSTRY

Ontario has one large laser company, Lumonics, and at least five smaller laser companies. The rapid development of a strong Ontario laser industry illustrates two important principles of industrial policy. First, one strong player can accelerate the

EXHIBIT XI.4

THE COMPETITIVE FACTORS IN DIFFERENT LASER APPLICATION SEGMENTS

Segment	1986 Market Share	Current Growth Rate/Year	Competitive Factors
Materials Processing (cutting, welding & marking)	21%	10%	Total system reliability; large, educated sales force
Scientific	20%	10-15%	Leading edge technology to fragmented markets; lasers only–no system, no documentation required
Medical	14%	15-20%	Unique market requires own sales force. Total system sale to well-defined market; large support organizations required
Optical Memories	13%	Doubling	Very concentrated OEM buyers. High volume, low cost, reliability are critical
Military	12%	10% +	Cost not a factor; technical capability is paramount
Telecommunications	6%	Flat*	Currently saturated market; long-term reliability is critical factor
Laser Printing	5%	5%	Very concentrated OEM buyers; cost & reliability trade-offs, although increasingly volume-driven cost competition is paramount
Other	9%	N/A	
Total	100%	10%**	

* 1986 sales actually dropped

**Growth rate calculated in total dollars, not in unit terms

Source: Telesis interviews and analyses of published sources development of a whole industry. Second, research projects involving the public and private sectors can be very effective when they are driven by commercial considerations. Unlike many cases where research has been led solely by the public sector, the laser industry shows how public and private sector cooperation can be geared toward marketable research efforts. Closer examination of the history of both Lumonics and the smaller companies also illustrates the challenges facing both threshold and start-up firms.

Lumonics and Ontario's five smaller laser companies had combined sales of $80.2 million in 1986, which represented 10.1 per cent of the world market in that year (See Exhibit XI.5). Markets for their products are varied and include scientific, industrial, military, and fibre optics applications. The cost to develop a new laser product in Ontario ranges from $20,000 for a CO_2 laser developed by Ultra Laser Tech to $3 million to develop and enhance a new product at Lumonics. Also worthy of note in Exhibit XI.5 are the important links these Ontario laser companies have with universities, research institutions, and larger companies.

Ontario's laser companies are strengthened by the existence of a significant laser research and development infrastructure, which includes the National Research Council, the University of Toronto, McMaster University, and York University. Each of these public sector institutions has developed outside relationships with Ontario laser firms. The importance of these close cooperative efforts between primary researchers at universities and research bodies and more commercially oriented researchers in business cannot be over-emphasized. Cooperation among the four key players has clearly been a critical factor in the success of the Ontario laser industry. These key players are Lumonics, the third largest North American laser company, which dominates at least one large market; the University of Toronto, which conducts state of the art research and development in close cooperation with Lumonics; McMaster University which cooperates with Lumonics on electro-optics and other aspects of laser research; and the National Research Council, which has a continuing program to follow up its long history of interchange with Lumonics.

As well as being a key participant in Canadian laser research and development, Lumonics has become a leader in industrial and scientific lasers. Lumonics began with the sale of $250,000 of private shares. Its founders come from Atomic Energy of Canada Limited and Leigh Instruments. Technology licensed from the Defence Research Establishment - Valcartier (DREV) enabled initial product development. Early U.S. customers such as MIT and

EXHIBIT XI.5

ONTARIO LASER COMPANIES*

Company	Major Markets		Laser Types	1986 Sales ($ Millions)	Cost to Develop Product	Links
Lumonics	Industrial Scientific	–marking –cutting	CO_2 YAG Excimer DYE	$65	$1-3 Million to enhance/ develop new product	University of Toronto NRC McMaster University
Optech System	Military		Semiconductor	$10.3	N/A	York University
PRA International (bought by Laser Photonics, U.S.)	Scientifc	–chemical	Nitrogen	$2.0	$300,000	
Opto-Electronics	Fibre optic users		Semiconductor	$1.8	N/A	McMaster University
Ultra Laser Tech	New Markets	–industrial –scientific	CO_2	$0.5	$20,000-100,000	RCA Spin-off
Antel-Optronics	Military, Industrial		Semiconductor	$0.6	$500,000-800,000	Linear Tech Spin-off

*Litton Systems Canada also manufacturers lasers as part of its ring laser gyroscope for aircraft guidance. The laser was developed elsewhere, but Litton Canada does perform some ongoing research and development.
Source: Telesis interviews and analysis.

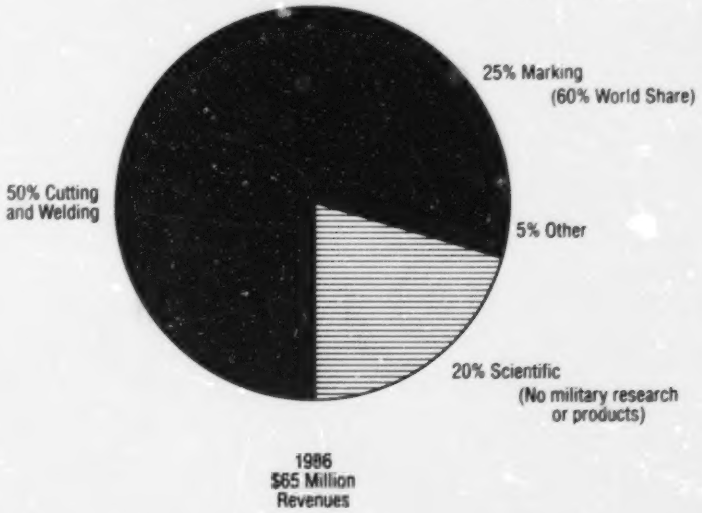
Los Alamos, together with Canadian R & D funding, helped the company develop a product line in research lasers. Later, U.S. contracts and NRC cooperation enabled Lumonics to develop very large CO_2 laser products. Frequent and informal contact with the universities broadened Lumonics' laser capabilities and its product line to include dye and excimer lasers.

In 1976, Lumonics entered the market for product marking lasers, and by 1980 the company had gone public. With the purchase of JK Lasers in 1982, Lumonics entered the solid state and medical laser markets with its first European manufacturing and distribution organizations. In 1983, the firm purchased Laser Identifications Systems and set up a U.S. manufacturing base to expand its presence in the electronic marking business. In 1985, with the purchase of Photon Sources, the firm enlarged its European presence and gained industrial cutting and drilling capabilities.

By 1986, Lumonics had annual sales of $65 million, focussed primarily in the cutting and welding segment and the marking industrial segment, which together account for 75 per cent of the firm's business mix (See Exhibit XI.6).

EXHIBIT XI.6

LUMONICS' BUSINESS MIX



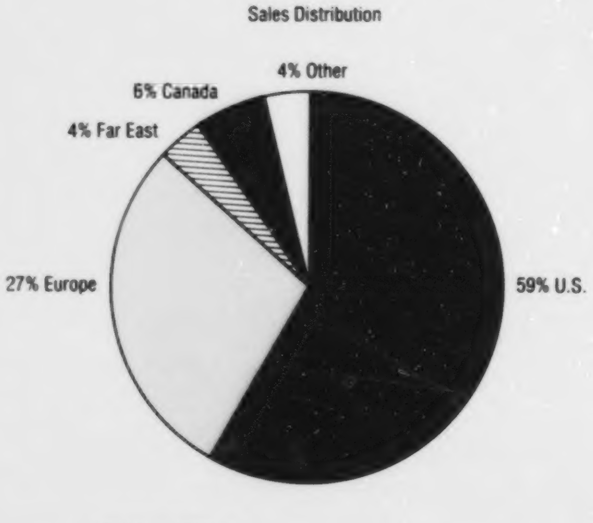
Source: Lumonics.

One of the key indicators of a threshold firm is a large proportion of international sales in its total activity. (For a complete description of what defines a threshold company, see Chapter VI of Volume 1 of the Premier's Council Report.) Lumonics certainly fits this definition, as 94 percent of its sales are to customers outside Canada, mostly in the United States and Europe (See Exhibit XI.7).

The remaining Ontario laser companies focus primarily on research lasers and contract research and development. Optech, Ultra Laser Tech, PRA, and Opto-Electronics are all firms concen-

EXHIBIT XI.7

LUMONICS' INTERNATIONAL PROFILE



Plants and Offices

Kanata, Ontario–Headquarters, Industrial Marking

Camarillo, California–Electronic Marking

Livonia, Michigan–Materials Processing

Rugby, England–Medical products

Munich, Germany–Materials Processing

Tokyo, Japan (sales only)

Source: Lumonics.

trating on research laser development, test equipment development, and contract engineering. The fifth small Ontario company, Antel-Optronics, is oriented toward mass manufacturing of laser-based products.

Antel-Optronics illustrates the challenges and opportunities available to manufacturing oriented laser companies just starting up. The company stands out as being highly entrepreneurial and growth-oriented. Starting in 1983 with an old Linear Technology integrated circuit line, Antel-Optronics now makes state-of-the-art high-speed opto-electronic chips. Current plans call for the firm to double its sales yearly; the capacity to do so is available, as growth of one thousand percent is possible without further major capital investment in plant and equipment. The challenges facing Antel are significant, however. In its markets it is a small company trying to develop opportunities in the automotive and aerospace businesses where applications have yet to be developed and where getting a foot in the door has proven difficult. Financially, Antel finds itself constrained by the limited capital resources available in Canada at a time when marketing and other activities are eating up cash. The company's engineering (rather than scientific) orientation, together with its Toronto location, render close cooperation with the NRC difficult.

One other general manufacturer, Litton Systems Canada, has as its main product a ring laser gyroscope, used to guide aircraft. Although the development of the gyro took place elsewhere, Litton Canada continues to perform considerable laser R & D, employing nearly one hundred staff in research fields such as aircraft display technology, fibre optics, gyroscopes, and manufacturing and process development.

THE COMPETITIVE CHALLENGE FOR LUMONICS

Eighteen years after its initial private share offering, Lumonics is well positioned for growth. The company has a broad product line and a presence in the markets of six major countries. It enjoys a leading position in excimer lasers and has a 60 per cent share of the world laser marking business, where only 10 per cent of the available market has been penetrated to date. Despite these strengths, Lumonics is at a critical competitive crossroad. Ontario's hopes in the laser industry are centred on Lumonics as the only large Canadian player. Despite its poor position in many other high technology businesses, Ontario has in Lumonics one of the three largest laser firms in the world. Nevertheless, in an industry characterized by high growth, rapid technological progress, and tough rationalization, Lumonics' competitive situation remains precarious.

Lumonics is the smallest of three companies that dominate the non-diode laser markets (See Exhibit XI.8). Spectra-Physics of California had $280 million in 1986 sales, making it more than four times the size of Lumonics. Coherent, another California company, had sales revenue of $184 million, nearly three times the sales revenue of Lumonics. In recent years the competitive environment has been so fierce that even these, the world's three largest laser companies, have sustained losses. Despite their losses, the three companies are still clearly in a class apart. The next largest North American competitor has less than $30 million in laser sales, and hundreds of others compete with less than $15 million annual sales.

As part of the rationalization and consolidation process in the laser industry, the three industry leaders have formed joint ventures or other linkages with outside firms as a way to strengthen their R & D, marketing, financing, or product development capacities. Spectra-Physics, partially owned by Ciba-Geigy, is cooperating with Xerox in a distribution joint venture. Coherent has made links with Lambda Physic and General Electric in an industrial machining joint venture. Lumonics has no joint ventures of comparable scale, but benefits from its relationship with Noranda, the company that owns 25 percent of Lumonics.

Despite being the world's largest laser company and offering a diverse range of products, Spectra-Physics has experienced roller coaster performance in recent years. Profits have ranged from a loss of $8.5 million in 1983 to a gain of $5.9 million in 1984 and back to a loss of $2.5 million in 1985. In 1986, Spectra-Physics spent nine percent of its sales, or U.S.$19 million, on research and development.

Coherent has a strong presence in medical lasers and representation in other major segments. This firm spent U.S.$14.8 million, or 11 percent of sales, on R & D in 1986.

Lumonics has one of the leading positions in the world in excimer lasers, a possibly revolutionary technology that will be used in plastic cutting and the manufacture of semi-conductors. Finally, Lumonics is internationally positioned with a broad product line in research, cutting, marking, and medical lasers.

Despite its position, Lumonics faces severe competitive challenges that are common to threshold Canadian technology companies trying to achieve world scale quickly. Lumonics faces U.S. competitors that have large and financially powerful corporate backers or partners such as Ciba-Geigy and General Electric, as well as support in the form of U.S. Defense Department contracts. Heavy annual R & D investments of $5 million or more are required of Lumonics just to maintain current business levels.

EXHIBIT XI.8

BIG THREE NORTH AMERICAN LASER COMPANIES

	Spectra-Physics	Coherent	Lumonics
Location	California	California	Ottawa
1986 Sales Cdn. $ Millions	$280	$184	$65
1986 Profits (Loss) Cdn. $ Millions	$1.1	($1.2)	($4.4)
Dominant Niche (non-scientific)	Bar Code Scanners	Medical (18% Share)	Marking (60% Share)
1986 R&D Cdn. $ Millions	$25.3	$19.7	$9.3
Current Focus	Cutting & Welding Machine Tools (Vertically integrated)	Medical (Vertically integrated)	Cutting & Welding Machine Tools

Source: Laser Focus and Telesis industry interviews

The cost of developing each successive product is increasing to the point where Lumonics must risk everything each time it develops a major product. Lumonics is also under financial pressures and faces skills shortages in trying to field specialized sales and service staff in several market segments in many countries.

Clearly, learning to manage R & D, manufacturing, and sales on three continents is difficult. But Lumonics' most important challenge may be to achieve the dominant position in the market for lasers used in cutting, drilling, and welding machine tools. This is a new, potentially high growth market where Lumonics has a small market share. Coherent has entered a joint venture with General Electric to tackle this market, but the major threat comes from Japan; the Toshiba corporation in particular has existing advantages in basic machine tools and state-of-the-art capabilities in lasers. To complement its laser capability and secure its position, Lumonics must gain access to machine tool technology.

Shifting competitive priorities have also affected Lumonics. As the markets for its laser products have evolved from research-oriented scientists to cost- and service-conscious hospitals and factories, Lumonics has had to compete on the basis of much more than its technical capability (See Exhibit XI.9). The key factors for success in various markets range from having a good laser product (in the market for research lasers) to the need for an intimate understanding of robotics and manufacturing technology (when the market is industrial lasers) to having an effective customer service capability in medical lasers.

Lumonics has been fortunate in the support it has received through Canadian public policy initiatives. The Canadian public sector R & D infrastructure at NRC and the universities have worked extremely well in transferring technology to laser companies. This success can be attributed to Canadian academic excellence in lasers and to the high level of informal exchange between public institutions and the private sector. The Ontario Development Corporation and federal R & D grants have also played significant roles in helping to fund Lumonics' growth. However, now that Lumonics has reached the level of a threshold company, where success means growing to world scale in product development, marketing, and service, there is a gap in government assistance programs. None of the government programs currently in existence is designed specifically to help with challenges such as sharing the risk on major new product developments or the substantial costs of opening new markets abroad. Lumonics will be hard-pressed to keep up with its competitors, which often have better access to financial resources, especially in the form of U.S. defence spending.

EXHIBIT XI.9

CHANGING SUCCESS FACTORS IN LUMONICS' MARKETS

Lumonic's Laser Markets	Buyer	Typical Applications	Buyer Criteria	Key Success Factors
Research Lasers	Scientists	New laser to test and use in experiments	Technical advancement	• Good laser science • Good scientific reputation
Medical Lasers	Doctors, Hospitals	Opthalmics, surgery	Cost and availability of customer service	• Medical knowledge • Large customer service organization • Sales force to cover disparate buying locations
Industrial Lasers	Manufacturing Engineers	Marking, cutting, drilling, alignment, and control	System cost, ability to integrate into production line	• Application and materials knowledge • Strong engineering to integrate system • Knowledgeable industry-aware sales force • Intimate understanding of robotics and manufacturing technology

Source: Telesis analysis based on interviews with Lumonics and other industry sources.

GENERAL INDUSTRY ISSUES

Apart from the specific challenges facing individual companies like Lumonics, Canada's laser industry faces several broad competitive issues. Canadian laser companies do not receive the same level of R & D support as their U.S. competitors; Canada does not energetically defend its patents; and many Canadian laser firms face the challenges of being small technology companies in world markets where scale is important.

U.S. laser companies have a significant financial advantage because of their access to U.S. government funding. There is no base level of R & D support in Canada comparable to the role of the U.S. Defense Department in the U.S. laser industry. U.S. government R & D funding for lasers currently includes projects with a combined value of $500 million annually (See Exhibit XI.10). This means that the amount spent annually by the U.S. government to fund laser R & D is nearly equal to the total value of sales of lasers around the world. Both Spectra-Physics and Coherent have access to a portion of this money—at least $10 million each—as do dozens of other U.S. laser companies. Lumonics does not, mainly because it is a Canadian firm. Given this disadvantage, Lumonics has made a strategic decision to avoid military markets.

EXHIBIT XI.10

U.S. GOVERNMENT LASER RESEARCH
AND DEVELOPMENT FUNDING
(U.S. $)

Department of Defense (DOD)	Star Wars	$30-50 Million Annually (Could increase)
Department of Energy (DOE)	Fusion Lasers	$300-400 Million Annually
Department of Defense	Blue Green Marine (Submarine Communication)	$65 Million Annually
DOD/DOE	Laser Test Site	$160 Million over 3 Years
National Science Foundation (NSF)	Scientific Research	$30 Million Annually

Note: Includes more than just laser research names
Source: Telesis interviews and analysis, 1987

A second issue for Canadian laser companies is that the Canadian Government does not energetically enforce its patent rights, eventually penalizing those who purchase licences. Although Lumonics pays licence fees to the Canadian government for the TEA laser, whose development was carried out by the Defence Research Establishment at Valcartier, its principal U.S. competitor in CO_2 laser marking systems does not. In this case, legal access to a Canadian licence has become a financial liability for Lumonics. Other countries vigorously defend proprietary technology important to their companies.

Finally, all Canadian laser firms suffer from the problems that accompany being small technology companies in world markets. These include the high cost of continuing R & D requirements, the "bet the company" dilemma encountered with each new generation of products, the fact that they have no large corporate parent like Toshiba to draw upon, and the need to field their products in and service all major world markets simultaneously. Other than basic R & D incentives, there are no government programs to help companies meet and overcome these competitive problems.

CHAPTER XII
BIOTECHNOLOGY

Biotechnology, an applied science that has been around for just 30 years, has all the features of what the Premier's Council referred to in Volume I of its report as an 'emerging industry'. The scientific basis of products such as biotechnology-derived pharmaceuticals is far from fully explored. Biotechnology is already changing the face of industries like agriculture, food processing, pharmaceuticals, and chemicals, but many applications remain to be discovered. To a large extent, competition in the industry is still driven by who has the latest scientific breakthrough, but product development and marketing capabilities are becoming increasingly important.

Early predictions that biotechnology would soon dominate many markets and make its investors millionaires have since been tempered by experience; many companies have failed, and many product ideas have never seen the commercial light of day. Even so, the impact of biotechnology will still be substantial.

Estimates of growth in the global biotechnology market, as well as its eventual size and the timing of development, are highly uncertain. The technology is only beginning to demonstrate its potential in products and processes in sectors like food processing, agriculture, energy, health care, and chemicals. However, biotechnology is expected to become a significant factor in major North American market sectors by the year 2000, principally as a result of the development of alternative energy sources and new food products and processes.

Despite the potential for growth, the market is highly competitive. A country the size of Canada needs to respond strategically and be selective in its investments. Basic and applied research and development in biotechnology require tremendous financial commitments; we simply cannot afford to be generalists in this field.

Canada is at present a bit player in international biotechnology. With total Canadian biotechnology R & D expenditures of less than $200 million in 1986, our investment is only 2.5 percent of the U.S.$6 billion invested in the United States. To have any real impact, Canada will need to focus its relatively small investment in areas where the potential for commercial success is already strong.

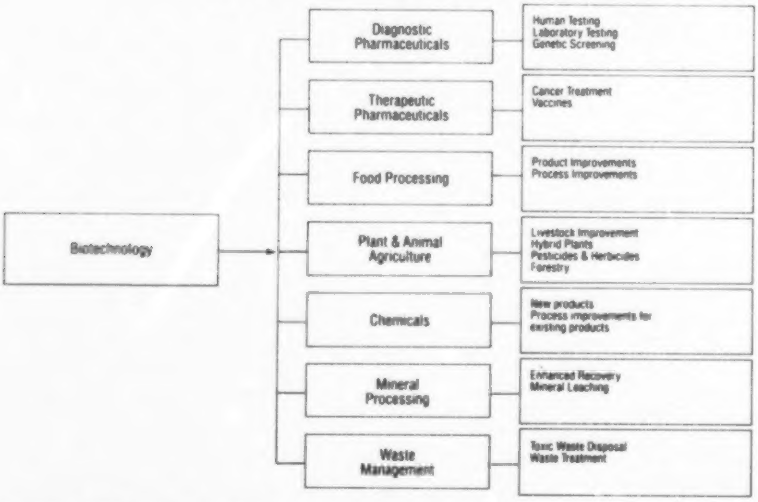
For example, biotechnology firms in Canada will need to identify the potential opportunities for their products in industries where Canada has a strong competitive position and respond accordingly. In some industries, such as pulp and paper or waste management, the appropriate response may be a major investment in biotechnology research specific to that industry. In sectors where Canada does not have an industrial strength, such as mass market pharmaceutical products, an even more targeted and focussed effort will be needed. In these sectors we lack indigenous multinational corporations to manufacture, market, and distribute products on a large scale. Small Canadian firms also run the risk of being gobbled up by major firms before they reach the commercial stage. New ways to build indigenous capability will need to be found.

BIOTECHNOLOGY: A NEW SCIENCE

The body of knowledge underlying biotechnology combines biological, chemical, and engineering sciences. Biotechnology can be defined as the application of scientific and engineering principles to produce goods and services through the use of living organisms and their products. The most common use of biotechnology is the fermentation and microbial processing to produce

EXHIBIT XII.1

Examples of Biotechnology Products



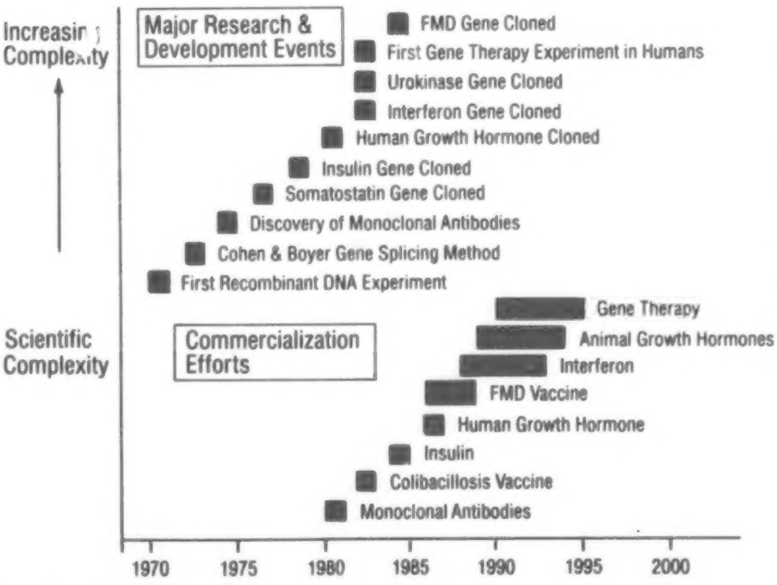
Source: Canada Consulting Group and Telesis.

alcoholic beverages, techniques that have been used for more than a thousand years in the brewing industry. However, the breakthrough that spurred the rapid advance in biotechnology happened in 1953 with the discovery of the structure of DNA. This in turn led to new technologies such as recombinant DNA, cell fusion, cell cloning, and bioprocess engineering. The results of this research were applied to new products and product improvements in several diverse fields (See Exhibit XII.1).

Although the science of biotechnology developed rapidly since that first breakthrough 30 years ago, the time and cost involved in transforming biotechnology discoveries into commercially viable products have been enormous (See Exhibits XII.2 and XII.3). A simple diagnostic test kit can cost as much as U.S.$5 million to develop, and a major new product such as the monoclonal delivery system is expected to cost $150 million. Once products are developed, companies still face long and costly food and drug

EXHIBIT XII.2

EXAMPLES OF THE BIOTECHNOLOGY R&D AND COMMERCIALIZATION PROCESS

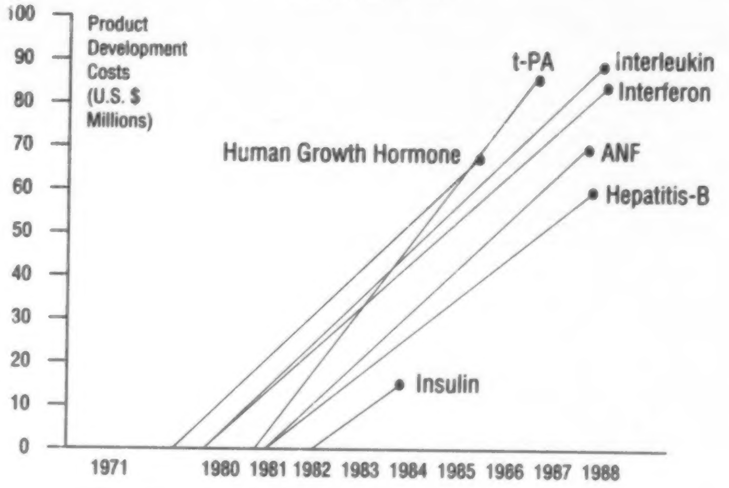


Source: Stanford Research Institute.

EXHIBIT XII.3

BIOTECHNOLOGY-BASED PRODUCT DEVELOPMENT TIMEFRAME

Pharmaceuticals



Source: Canada Consulting and Telesis

approval processes. However, products that have reached the consumer, such as human insulin and growth hormone, have proven very successful, and projections for the future of biotechnology as an industry still look promising indeed.

To date, all significant biotechnology products, especially in the health care field, have come out of the United States. Canada's biotechnology effort is almost entirely still in the research stage, with a few important exceptions.

SIZE AND STRUCTURE OF THE CANADIAN INDUSTRY

Industrial biotechnology research and development in Canada takes place primarily in small independent, privately owned firms. There are just over 100 of these firms, which invest a total of $65.6 million in biotechnology research (See Exhibit XII.4). Most of these firms (including close to 50 in Ontario) are primarily research houses sustained by R & D grants and consulting contracts rather than product sales. In Ontario, the largest annual biotechnology R & D expenditure in industry is $15 million at Allelix, a firm established with strong provincial government involvement. The next largest expenditures are at the Connaught Research Institute ($3.3 million) and Eli Lilly Canada ($2.5 mil-

EXHIBIT XII.4

THE BIOTECHNOLOGY INDUSTRY IN CANADA

	# Of Firms	Percentage of Total	Reported R&D Expenditures* ($000)	Percentage of Total	Average R&D Per Firm ($000)	Reported Scientific Personnel**	Percentage of Total
Health Care***	31	29%	$27,300	42%	$900	368	41%
Food Processing	22	20%	8,000	12%	400	119	13%
Animal & Plant Agriculture	13	12%	18,400	28%	1,400	211	24%
Forestry	11	10%	4,500	7%	400	49	6%
Engineering	10	9%	2,000	3%	200	26	3%
Waste Treatment	8	7%	600	1%	80	23	2%
Mineral Processing	5	4%	200	3%	40	21	2%
Other	10	9%	2,900	4%	290	76	9%
Total	100	100%	$65,593	100%	$596	893	100%

* R&D expenditures were reported by 78 firms
** Scientific personnel were reported by 90 firms
***Includes expenditures on clinical trials
Source: Ministry of State for Science & Technology, 1986

EXHIBITS XII.5

ONTARIO'S LARGEST BIOTECHNOLOGY LABORATORIES

	R&D Expenditures (1985-86) $ 000s	Number of Scientific Staff In-House
Allelix	$15,000	140
Connaught Laboratories	3,300	20
Eli Lilly Canada	2,481	22
Syntex	2,000	NA
Cangene	1,750	18
Labatt Brewing	1,600	35
Denison Mines	1,600	1
Total	$27,731	236
Remaining 39 Firms	$8,561	176

Source: Ministry of State for Science & Technology, 1986.

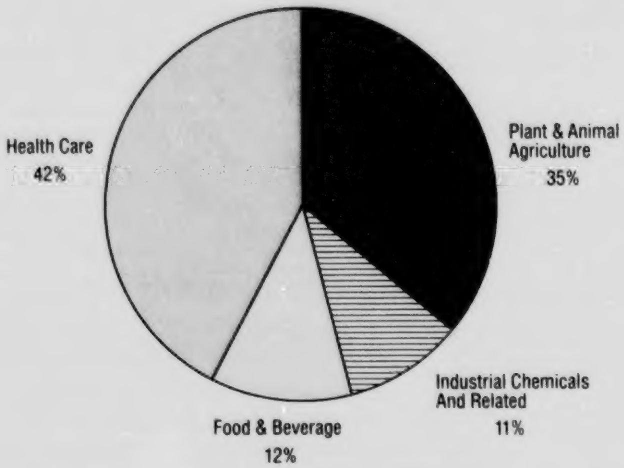
lion) (See Exhibit XII.5). Private sector biotechnology research in Canada takes place predominantly in the field of health care (42 percent) and plant and animal agriculture (35 percent) (See Exhibit XII.6). Although some of this work takes place in large, established firms, most is carried out by small start-up companies (See Exhibit XII.7).

The fragility of Canada's private sector biotechnology efforts makes the public sector role especially important. Sixty-five percent of Canadian biotechnology R & D funding comes from governments, mainly at the federal level (See Exhibit XII.8). Analysis of federal government biotechnology spending shows that the bulk of funds goes to universities (See Exhibit XII.9). Less than ten percent goes to industry, and the balance is invested in internal government research. Most of the federal investment in biotechnology research is distributed through the National Research Council, the Medical Research Council and the Natural Sciences and Engineering Research Council (NSERC) (See Exhibit XII.10). The National Research Council has established

EXHIBIT XII.6

PRIVATE SECTOR BIOTECHNOLOGY IN CANADA

Distribution of Research and Development
Expenditures by Sector
1985
$65.6 Million



Source: Ministry of State for Science & Technology

two institutes for biotechnology research: the Plant Biotechnology Institute (PBI) in Saskatoon and the Biotechnology Research Institute (BRI) in Montreal.

PBI is staffed by 110 researchers and operates on an annual budget of $7.7 million. It plays an active scientific role, publishing close to 70 papers a year, but commercialization of its research discoveries has proceeded at a slower pace; PBI has negotiated a total of six licensing agreements with three companies to date. Montreal's BRI opened its doors in the spring of 1987. It will employ 240 staff and provide facilities for an additional 150 researchers from industry and universities. BRI will contain four laboratory units: biochemical engineering and fermentation processes, genetic engineering, protein engineering, and cell fusion, and molecular immunology.

In addition to funding and carrying out biotechnology

EXHIBIT XII.7

DISTRIBUTION OF R&D EXPENDITURES AND STAFF
Established Versus Start-Up Companies

	R&D Expenditures 1985		Research Staff	
	$ 000s	%	#	%
Biotechnology Start-ups	$51,012	77.8	732	82.0
Established Companies	14,581	22.2	161	18.0
Total	$65,593	100.0%	893	100.0%

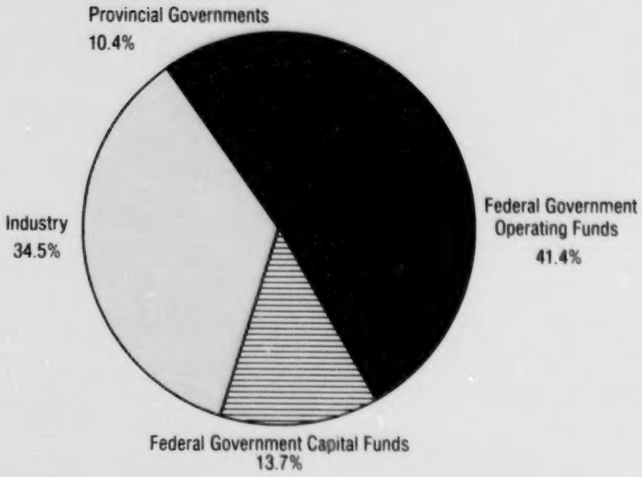
Source: Ministry of State for Science & Technology, 1986.

EXHIBIT XII.8

TOTAL BIOTECHNOLOGY RESEARCH AND DEVELOPMENT IN CANADA

1985-86

Total: $190 Million



Source: Ministry of State for Science & Technology

research, the federal government also plays a regulatory role. At present there are 37 laws administered by eleven government departments that can affect the commercialization of biotechnology-related R & D. The federal and provincial governments have joined forces to seek ways to ease this regulatory burden while ensuring that public safety concerns are met.

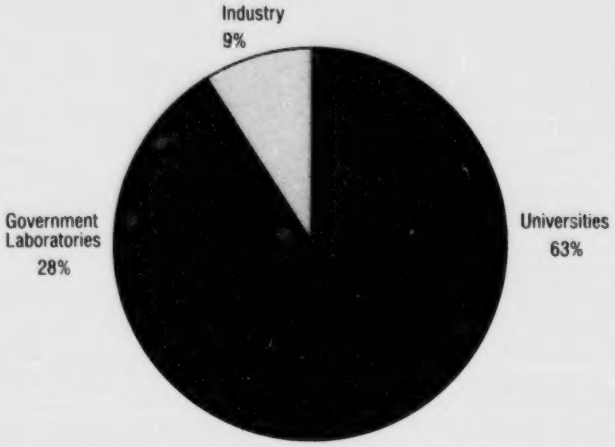
At the provincial level, the Ontario government also takes an active role in biotechnology research. Ontario's $7 million annual expenditure in this field represents 34 percent of all Canadian provincial biotechnology research funding. Ontario's approach to biotechnology research has been based mainly on assisting to establish Allelix and staffing it with world-class scientists. Like many publicly funded institutions, Allelix has come in for its share of criticism. Several years of research have not yet yielded a commercially viable product, leading to questions about the overall viability of the company.

EXHIBIT XII.9

DISTRIBUTION OF CANADIAN FEDERAL GOVERNMENT BIOTECHNOLOGY R&D FUNDIING (OPERATING FUNDS ONLY)

1985-86

Total: $78.6 Million



Source Ministry of State for Science & Technology

Nor is concentrating research funding in universities without pitfalls. The development of a trial natriuretic factor (ANF) at Queen's University provides a case in point. ANF, with potential for use in the treatment of hypertension and coronary arrest, was discovered by a Queen's University research team and patented in 1983. In an attempt to raise interest in ANF research and obtain funding, the researchers published their results. Firms such as Monsanto and Merck were quick to recognize the potential value of this new product, and both undertook major research efforts of their own. The Queen's University patent covered only one ANF composition, and the companies were soon able to receive patents on their own ANF developments. Canadian funding from NSERC and Ontario's IDEA Corporation was insufficient to push the Queen's University research through to commercial development. Despite the investment, and the fact that the initial discovery was made in Ontario, it is unlikely that Ontario scientists or firms will benefit from the projected $300 million market for ANF products.

EXHIBIT XII.10

CANADIAN FEDERAL GOVERNMENT ALLOCATION OF BIOTECHNOLOGY R&D FUNDS
(OPERATING FUNDS ONLY)
1985-86
$ Thousands

Institution	Internal	External	Total	Person Years
National Research Council	$10,894	$14,120	$25,014	358
Medical Research Council	—	20,977	20,977	—
N.S.E.R.C.*	—	15,766	15,766	—
Agriculture Canada	9,500	2,150	11,650	171
D.R.I.E.**	—	1,500	1,500	—
Energy Mines & Resources	75	1,200	1,275	9
Environment Canada	726	546	1,272	15
Canadian Forestry Service	323	300	623	52
Health And Welfare Canada	342	27	369	27
Fisheries And Oceans	75	96	171	5
Total	$21,935	$56,682	$78,617	637

*Natural Sciences and Engineering Research Council
**Department of Regional Industrial Expansion
Source: Ministry of State For Science & Technology

THE INTERNATIONAL CONTEXT

In terms of R & D investment—still the best measure of activity in this emerging industry—the United States is by far the dominant player. With annual expenditures of close to $3 billion, U.S. public sector investment is nearly ten times larger than that of any other nation (See Exhibit XII.11). This investment is matched by a $3 billion commitment to biotechnology R & D in the private sector. To put this in perspective, three U.S. companies spend more on biotechnology R & D than the total Canadian public and private sector investment combined (See Exhibit XII.12). Five U.S. firms each spend more than the entire investment by Canadian industry. In an industry where today's R & D investment is a strong indicator of future market dominance, it is clear what country will be tomorrow's biotechnology industry leader.

Following in the U.S. wake is Japan's industry-oriented biotechnology research. Typically, the Japanese are concentrating on commercial applications rather than basic research. They are forming partnerships with U.S. firms to gain access to their long-term research results, especially in pharmaceutical R & D.

EXHIBIT XII.11

PUBLIC SECTOR FUNDING OF BIOTECHNOLOGY WORLDWIDE
1985-86

Country	Annual Expenditure $ Millions
United States	$2,835
Japan	412
France	335
West Germany	327
United Kingdom	267
Sweden	150
Denmark	134
Switzerland	120
Canada	79
Italy	69
Belgium	49

Source: European Biotechnology News/M.O.S.S.T.

EXHIBIT XII.12

BIOTECHNOLOGY R&D EXPENDITURE:
A Comparison of U.S. Corporation and Total Canadian Spending

Company	Biotechnology R&D 1985 (Cdn. $000s)
Monsanto	$266,500
Merck	245,520
Dupont	198,000
Canadian Federal Government*	**104,617**
Genentech	85,661
Cetus	79,200
All Canadian Industry	**65,593**
Genetics Institute	25,596

*Includes capital expenditures.
Source: Ministry of State for Science & Technology, Annual Reports, Canada Consulting Group analysis.

The interplay between Japan and the United States in the development of many emerging technologies in recent years has been a delicate balance of all-out competition and strategic alliances. Biotechnology is no exception. An examination of the players and their strengths and weaknesses offers some insight into how the commercialization and diffusion of biotechnology and its products will develop.

The United States' World Leadership In Biotechnology

The United States realized the potential of biotechnology relatively early and therefore gained a significant lead in the race. Large U.S. corporations, particularly in the health care and pharmaceutical industries, established internal R & D capabilities. At least 30 major U.S. firms as diverse as Dow Chemical, IBM, General Foods, and 3M have launched substantial in-house biotechnology development programs (See Exhibit XII.13).

EXHIBIT XII.13

MAJOR U.S. CORPORATIONS WITH IN-HOUSE DEVELOPMENT PROGRAMS IN BIOTECHNOLOGY

Company	Research Area
Abbott Laboratories	Pharmaceuticals
Allied Chemical Corp.	Agriculture
American Cyanamid	Agriculture
Baxter Travenol	Pharmaceuticals
Bristol Myers	Pharmaceuticals
Campbell Soup	Pharmaceuticals
Celanese Corp.	Chemicals
Ciba-Geigy	Pharmaceuticals
Corning Glass	Chemicals
Dart & Kraft	Chemicals
Dow Chemical	Agriculture, Pharmaceuticals
Eastman Kodak	Pharmaceuticals
E.I. Du Pont	Pharmaceuticals
Eli Lilly	Agriculture, Pharmaceuticals
FMC Corp.	Pharmaceuticals
General Electric Co.	Electronics, Environment
General Foods	Plant Agriculture
W.R. Grace & Co.	Plant Agriculture, Pharmaceuticals
I.B.M. Corp.	Electronics
Hoffman-LaRoche	Pharmaceuticals
International Minerals & Chemicals Corp.	Environment, Agriculture
3M Co.	Pharmaceuticals
Miller Brewing Co.	Agriculture
Monsanto Co.	Agriculture, Pharmaceuticals
Ortho Pharmaceutical	Pharmaceuticals
Pfizer Inc.	Pharmaceuticals
Phillips Petroleum	Environment

Source: U.S. Congress, Office of Technology Assessment.

In conjunction with their internal efforts, companies have poured a large amount of equity capital into new biotechnology companies. Much of this has been from the stock market, but significant amounts have come from investments by established companies as well (See Exhibit XII.14). The equity investment

EXHIBIT XII.14

EXAMPLES OF CORPORATE INVESTMENTS IN U.S. BIOTECHNOLOGY START-UPS

Investing Company	Biotechnology Start-up	Investment (U.S. $ Millions)
Abbott Laboratories	Amgen	5.0
Allied Corporation	Genetics Institute	10.0
Baxter Travenol	Genetics Institute	5.0
Campbell Soup	DNA Plant Technologies	10.0
Continental Grain	Calgene	1.0
Dow Chemical	Collaborative Research	5.0
Flavor Corporation	Genentech	9.0
Johnson & Johnson	Enzo Biochem	14.0
Eli Lilly	International Plant Research Institute	5.0
Lubrizol	Genentech	25.0
Martin Marietta	Chiron	3.25
Monsanto	Biogen	20.0
Phillips Petroleum	Salk Institute of Biotechnology	10.0
Rohm & Hass	Advanced Genetic Sciences	12.0
Schering-Plough	Biogen	12.0
Standard Oil of California	Cetus	12.9
Standard Oil of Indiana (AMOCO)	Cetus	14.0

Source: U.S. Congress, Office of Technology Assessment.

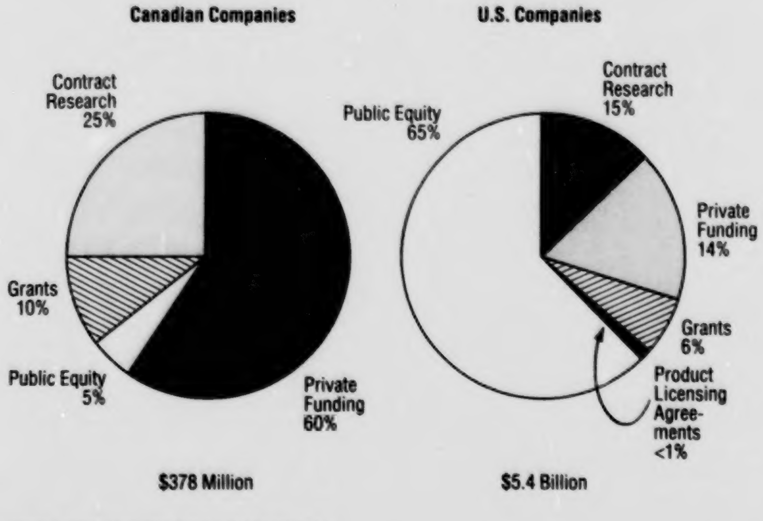
raised in the stock market plays a critical role in fuelling the development of the U.S. industry. While in Canada only five percent of non-debt financing of biotechnology companies comes from public equity financing, in the United States that figure is 65 percent (See Exhibit XII.15). In 1986, for example, sixteen U.S. biotechnology firms went public, raising an average of $29 million each. Only two Canadian firms went public that year, one raising $14 million, the other $3 million.

Today the U.S. industry is almost evenly divided between new biotechnology companies and established firms that have become involved in biotechnology. In both cases the largest number of firms is in the pharmaceutical sector, followed by agriculture. Smaller segments include food processing, chemicals, and waste management (See Exhibit XII.16).

Health care and pharmaceuticals are also the main recipients of U.S. biotechnology investment. The U.S. domestic market accounts for almost one-quarter of the world pharmaceutical market, and U.S. firms dominate the industry all over the world (See Exhibit XII.17). Although close to $3 billion has been

EXHIBIT XII.15

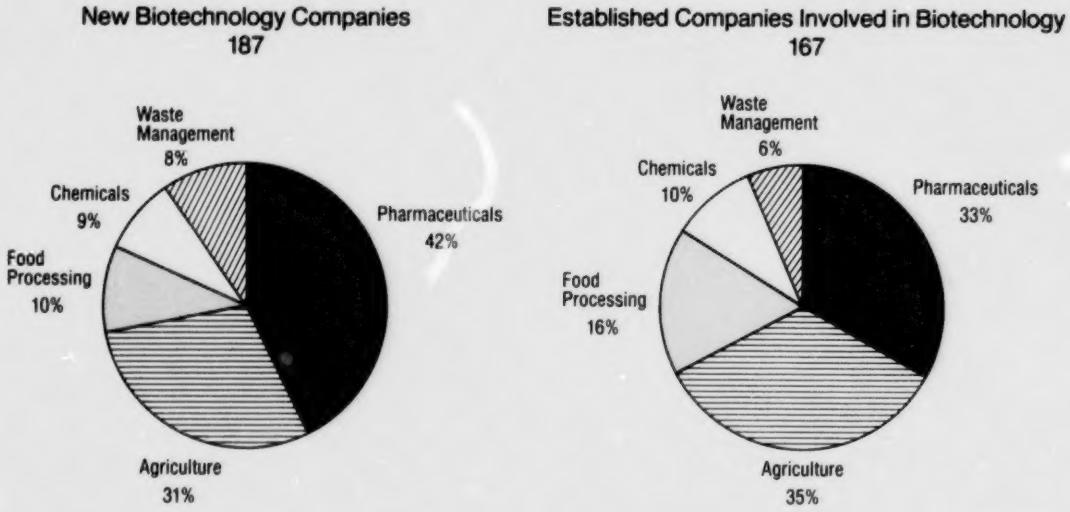
EQUITY FUNDING OF THE BIOTECHNOLOGY INDUSTRY
CANADA VERSUS U.S.
1976-1985



Source: Canada Consulting Group and Arthur Young.

EXHIBIT XII. 16

U.S. BIOTECHNOLOGY START-UPS AND ESTABLISHED COMPANIES



Source: U.S. Congress, Office of Technology Assessment.

EXHIBIT XII.17

INTERNATIONAL PHARMACEUTICAL INDUSTRY

Country	Number Of Companies In Top 20 Worldwide*	Reported 1985 R&D Expenditures (U.S. $ Millions)	Pharmaceuticals Under Development 1985	Pharmaceuticals Reported In Clinical Trials 1985
United States	12	$1,800	371	157
Switzerland	3	774	145	83
West Germany	3	650	100	56
Japan	1	125	41	12
France	1	110	26	18
Total	20	$3,459	683	326

*Ranked by revenues.

Source: Arthur D. Little/U.S. Food and Drug Administration.

EXHIBIT XII.18

F.D.A.-APPROVAL BIOTECHNOLOGY-BASED PHARMACEUTICALS

Year Approved	Company	Product	Application
1982	Genentech	Insulin	Diabetes
1985	Genentech	Human Growth Hormone	Dwarfism
1986	Burroughs-Wellcome	Dizibene	Digoxin Antidote
1986	Ortho Pharmaceutical	Orthoclone	Acute Renal Rejection
1986	Hoffman-LaRoche	Interferon	Leukemia
1986	Schering-Plough	Interferon	Leukemia
1986	Speywood Labs	Anti-Hemophiliac	Hemophilia
1986	Merck	Hepatitis-B Vaccine	Hepatitis-B

Source: U.S. Food and Drug Administration.

invested by U.S. corporations developing biotechnology for this sector, only eight new products have actually been approved to date. The first, Genentech's insulin product, was approved by the U.S. Food and Drug Administration (FDA) in 1982. Genentech received approval for a second drug in 1985; in 1986, six more drugs received FDA approval (See Exhibit XII.18). These products generally took five to ten years to develop and cost as much as $100 million each.

Despite the few highly publicized new biotechnology products, most of the revenue of U.S. biotechnology firms does not come from product sales. Many of the leading biotechnology firms, such as Genentech and Cetus, are still sustained largely by contract research and interim income from funds raised in public offerings (See Exhibit XII.19).

EXHIBIT XII.19

U.S. BIOTECHNOLOGY LEADERS
Product Sale Revenue as a Percentage of Total Revenue

Company	Total Revenue U.S. $ Million	Product Revenue as Percentage of Total
Genentech	$89.6	5.8%
Cetus	57.2	1.7
Amgen	23.4	3.5
Centocor	22.3	31.4
Biogen	21.4	0.0
Genetics Institute	21.3	0.0
Genex	16.6	81.3
Collaborative Research	9.5	52.6
Molecular Genetics	8.3	16.9
Damon Biotech	3.7	43.6
Average	$27.3	13.2%

Source: Annual Reports/Consulting Resources Corp.

Federal government funding also supports the U.S. biotechnology effort. More than $2 billion is allocated annually to research, primarily to the National Health Institutes, the National Science Foundation, and the Department of Agriculture (See Exhibit XII.20). Companies have also been granted research monies through the Small Business Innovative Research Act. Under the Act, a certain proportion of funds allocated to relevant government departments and agencies has to go into firms with fewer than 500 employees. Between 1982 and 1985, biotechnology firms received $36.4 million out of a total of $375 million in U.S. federal grants.

Japan: A Strong Second Player

Unlike the U.S. situation, the Japanese biotechnology effort is concentrated almost entirely in large corporations; there are virtually no small start-up companies. Instead of investing in innovative new businesses, Japanese companies have sought joint ventures, primarily with U.S. firms, to broaden their technological capacity (See Exhibit XII.21). As a result, U.S. firms are gaining access to the Far East markets, while Japanese firms are acquiring the benefits of the substantial American R & D effort.

A survey by the Japanese Ministry of International Trade & Industry (MITI) found that there were 122 firms in Japan conducting biotechnology research in 1983. Many of these were in chemical (usually pharmaceutical) research; the rest were in food processing, medical applications, pulp and paper, and others. MITI has played a coordinating role in encouraging the development of the Japanese biotechnology industry, sponsoring, for example, the creation of the Bioindustry Development Centre (BIDEC), which has 165 industry members from a wide range of sectors. BIDEC's mandate includes data collection, public relations, surveys, research, and international cooperation.

The European Role

Although they are late entrants in the biotechnology race, both the private and the public sector in Europe are taking steps to increase their strength. The Commission of the European Economic Community has established a biotechnology program to encourage research and development in its member countries. The program, described as a five-year "biotechnology mobilization strategy", is sponsoring pre-competitive research with the objective of enhancing long-term industrial and agricultural competitiveness. This is to be accomplished by improving science and technology infrastructure and eliminating impediments to commercialization of the products of biotechnology research.

EXHIBIT XII.20

U.S. FEDERAL FUNDING OF BIOTECHNOLOGY
1984-87

U.S. Government Department/Institute	(U.S. $Million)			
	1984	1985	1986	1987**
National Health Institutes	1,633	1,839	1,836	1,801
• Direct	521	639	636	621
• Broadly-Based	1,112	1,200	1,200	1,180
National Science Foundation	61	82	89	109
Department of Agriculture	39	77	74	79
Department of Energy	38	43	43	44
Department of Defense	33	34	43	49
Department of Commerce*	1	1	3	4
Environmental Protection Agency	0	2	6	8
Total	$1,805	$2,078	$2,094	$2,094

* Includes Bureau of National Standards.
**Estimate.
Source: National Science Foundation.

EXHIBIT XII.21

JOINT FAR EAST MARKETING VENTURES BETWEEN U.S. AND JAPANESE BIOTECHNOLOGY COMPANIES

Biotechnology Company	Joint Venture Partner	Product
Amgen	Kirin	Colony Stimulating Factor
Amgen	Kirin	Erythropoietin
Genetics Institute	Chugai	Erythropoietin
Biogen	Teigin	Factor VIII
Immunex	Ajinomoto	Interleukin-2
Biogen	Shionogi	Interleukin-2
Biogen	Sumitomo	Insulin-like Growth Factor
Burroughs-Wellcome	Sumitomo	Alpha-Interferon
Biogen	Shionogi	Gamma-Interferon
Genentech	Daichi-Seiyaku	Gamma-Interferon
Biogen	Yamanouchi	Lipocortin
Genentech	Mitsubishi	Tissue Plasminogen Activator
Integrated Genetics	Toyoba	Tissue Plasminogen Activator
Genentech	Fujisana	Tumour Necrosis Factor
Biogen	Suntory	Tumour Necrosis Factor

Source: Cable, Howse & Ragen.

The private and public sectors in the United Kingdom, France and West Germany are the most active in the European biotechnology effort (See Exhibit XII.22). As in Japan, many European companies have formed joint ventures with U.S. firms to gain access to biotechnology research (See Exhibit XII.23). These alliances are largely in the field of therapeutic and diagnostic pharmaceuticals.

EXHIBIT XII.22

EUROPEAN & U.K. COMPANIES AND PUBLIC ENTITIES UNDERTAKING BIOTECHNOLOGY RESEARCH AND DEVELOPMENT

1985

	Number of Companies	Number of Research Institutes & Universities	Total
United Kingdom	210	44	254
France	122	15	137
West Germany	96	40	136
Belgium	60	13	73
Switzerland	54	17	71
Sweden	50	18	68
Italy	43	18	61
Netherlands	33	26	59

Source: Stanford Research Institute.

THE MAJOR ISSUES

An overriding conclusion about the development of the global biotechnology industry to date is that commercialization has turned out to be more challenging and much more costly than initially believed. Overcoming the scientific barriers is proving more difficult than expected, thus requiring greater expenditures on research and development. The costs of going to market with an approved product have turned out to be formidable. Regulatory approval processes have become exceedingly complex and time-consuming, partly because agency staff have little experience with some of the scientific aspects of biotechnology. Above all, the process of scaling up from production at the laboratory bench to production for commercial purposes is proving to be the major scientific obstacle.

In Canada, these issues are compounded by our lack of large indigenous firms with the resources to manufacture, market, and distribute biotechnology-derived products competitively. Small firms gearing up to fill this role are impeded by Canada's underdeveloped financial markets for high technology ventures. There

EXHIBIT XII.23

JOINT VENTURES BETWEEN EUROPEAN AND U.S. BIOTECHNOLOGY COMPANIES

European Company (Parent)	Country	U.S. Biotechnology Company	Product
Behringwerke (Hoechst)	West Germany	Immunex	Therapeutics
Bioferon	West Germany	Biogen	Therapeutics
Burroughs-Wellcome	West Germany	Biogen	Therapeutics
Gruenenthal	West Germany	Genentech	Therapeutics
Kabivitrum	Sweden	Biogen, Genex, Genentech	Therapeutics
Recordati	Italy	Hana Biologics	Therapeutics
Sandoz	Switzerland	Collaborative Research, Genetics Institute	Therapeutics
Schering	West Germany	Genex	Therapeutics
Sigma-Tau	Italy	Unigene Labs	Therapeutics
Boehringer-Mannheim	United Kingdom	Hybritech	Diagnostics
Cutter Labs (Bayer)	West Germany	Genetic Systems	Diagnostics
Hoffman-La Roche	Switzerland	Centocor, Damon, Genentech	Diagnostics, Therapeutics
Institut Pasteur	France	Genetic Systems	Diagnostics
Miles Labs (Bayer)	West Germany	Genetic Systems	Diagnostics
Roussel UCLAF	France	Cetus	Diagnostics
Speywood Labs	United Kingdom	Genentech	Diagnostics

Source: *Science*, Vol. 232

is no shortage of scientific personnel for the industry, but firms are having difficulties finding personnel with appropriate product development and marketing expertise. Such individuals are rare even in the United States and are expensive and difficult for Canadian firms to recruit.

Ontario is at a critical juncture in biotechnology in terms of our ability to be competitive and take advantage of the business opportunities presented by this emerging technology. We have developed some strengths in biotechnology, but these are limited by the lack of commercial focus and marketing capabilities. As market forces continue to play a growing role in the biotechnology industry, small research houses will have to form alliances with companies with sufficient scale to commercialize and market their products. Unfortunately, Canada's policies and strategies have focussed on research and thus do not meet this need; as a result, it is unlikely that Canadian firms will be able to maintain their independence and nationality. A Canadian industry made up of small research-oriented biotechnology companies cannot compete in a global marketplace that is increasingly dominated by large multinationals.

The results of a recent survey of biotechnology companies in the United States underline the importance of size for survival in this industry. Small companies (up to 50 employees) had an average life span of only 19 months, while larger firms (more than 135 employees) had life spans of 91 months.

In summary, the challenge facing the biotechnology industry in Canada is that its present strengths do not correspond to the essentials for survival in a highly competitive environment. Canadian companies are small in an industry where size counts in success. Pharmaceuticals have been a proving ground for biotechnology products and processes, but Canada has no indigenous multinational base of pharmaceutical companies. The ability to commercialize is quickly becoming the predominant force behind global competition in the industry, but Canada's funding policies, investment strategies, and industry strengths are still research-oriented.

These observations and conclusions do not lead directly to a strategy for Ontario's biotechnology industry. But they do raise a number of questions about the most appropriate course of action.

- Will the biotechnology industry develop with sufficient niche opportunities to enable small firms to compete successfully internationally?
- Will small companies be able to parlay research contracts with large companies into sustainable biotechnology businesses, or will they end up as research houses?

- Have the financial markets moved past the point where research capability alone is sufficient to secure financing?
- Do Canadian companies have the resources and apparent strengths to develop or attract first-rate production and marketing capabilities, and can multinational support be garnered to build indigenous Canadian biotechnology capability?
- Will the provincial government's approach to biotechnology provide the necessary policy environment to encourage the development of commercially successful companies?
- Will the federal bias towards in-house research foster sufficient and timely transfer of technology to the private sector?

Questions like these should serve to focus debate on the critical issues. The answers can in turn be used to develop a combined public and private sector strategy to meet the competitive challenge of the global biotechnology industry.

CHAPTER XIII
THE NUCLEAR INDUSTRY

Canada's nuclear industry is an amalgam of public, quasi-public and private sector interests, including governments, Crown corporations, provincial utilities, licensing bodies, and private sector mining, manufacturing, and engineering companies. The energy-related sector of the industry encompasses uranium mining and refining, the production of electricity using nuclear generators, the manufacture of the CANDU reactor, CANDU-related research and development, and service to utilities using nuclear generators. The non-energy sector of the industry includes nuclear medicine (both diagnosis and treatment) and nuclear research and development in such fields as medicine, industrial diagnostics, and materials. Atomic Energy of Canada Limited (AECL) is a central player in both the energy and the non-energy sector, while Ontario Hydro has been a dominant force in the energy sector.

In this chapter we will examine the origins, growth, and prospects for the Canadian nuclear energy industry in some detail and look more briefly at the industrial potential of other nuclear industry products. The nuclear energy industry represents an interesting case study of an emerging high-technology industry which did not meet the general expectation of becoming a stable high growth business. It is now in the process of a substantial restructuring world-wide, and Canada's relatively small sector is quite vulnerable. The dependence of Ontario Hydro on its existing nuclear plants and the supplier base which supports them means that the Province has to be especially concerned about the future health of the industry. This chapter will discuss several alternative directions for the industry, including sustaining the existing base through new Canadian nuclear plants, investing in cost reduction opportunities to help win export orders, and pursuing diversification opportunities in related businesses. Of course, a fourth alternative is to mothball the industrial capability until market prospects improve. The risk of mothballing is that it would be very difficult and costly to try to re-establish the industry at a later date, if in fact it would be at all possible.

Over the last 37 years, the federal government has spent about $4.0 billion in nuclear energy R & D. This represents the single largest R & D effort in the country's history, and it has led to the development of a nuclear industry that has created 30,000 direct jobs, many in high-tech fields. Canada, as a small country, was fortunate in being able to develop the CANDU. A unique time, circumstance, and set of personalities all combined to make a scientific dream a technological reality. While the CANDU owes its initial existence to those technically imaginative and entrepreneurial individuals who spawned and nurtured it, they could only take the technology so far.

CANDU is unfortunately an orphan technology, with a weak industrial base, even weaker political linkages, and as yet a large unrealized potential. The nuclear program in Canada has developed with too narrow a focus. Responsibility for the development of CANDU, though resting at the federal level, has been largely influenced by Ontario Hydro. Strategic business decisions, such as product standardization, cost reduction, and product delivery have not been well planned but rather have evolved over time.

CANDU was developed in an era of strong economic growth, with the prospects of a never-ending demand for electricity. Nuclear energy was seen to be one logical solution. CANDU had strong domestic market support and its worth was self-evident; marketing was deemed relatively unimportant and long term planning for international competitiveness was not emphasized. The market for CANDU was so healthy and prospects were so secure that the proponents of CANDU believed that it would sell itself.

CANDU spawned an industry of component suppliers focussed on selling to Crown corporations with a cost-plus orientation and public policy mandates. The lack of a strong business focus and a private sector base impeded the technology from becoming a product business based on competitive costs.

Now, the future of CANDU is open to speculation, with the realization of its untapped potential hanging in the balance. Key decisions must be made by both government and industry. Clearly, shifting nuclear energy from a cost-plus environment into a product business must be a key element of any approach. Privatization and joint venturing may also be components in the plan to secure CANDU's future. Whatever strategic approach is decided, it must be pursued in a decisive and single-minded fashion.

Development of the CANDU

As Canada's nuclear industry has developed since the 1950s, Crown corporations and private companies have become involved in various aspects of the industry. Uranium mining and upgrading are carried out largely by private sector firms, although provincial and foreign governments are becoming increasingly involved in this sector; uranium refining is provided by Eldorado Nuclear Limited, a federal crown corporation.[1] Nuclear energy efforts have focussed entirely on the CANDU, a proprietary reactor technology developed through the joint efforts of the governments of Ontario (through Ontario Hydro) and Canada (through AECL). Electrical utilities are responsible to their respective provincial governments for their decisions to purchase nuclear generating facilities, as well as for their construction and operation. The federal Atomic Energy Control Board (AECB), along with other government departments and ministries, regulates and licenses nuclear power plants. Manufacturing firms in Canada supply components for CANDU under contract to AECL or Ontario Hydro. Engineering and consulting firms provide engineering, project management, and reactor servicing for CANDU both at home and abroad.

Ontario Hydro, with 90 percent of the in-service CANDU capacity in Canada, plays a key role in the energy application of nuclear technology. (This corporation, which is one of Ontario's largest, is examined in more detail in chapter XIV of this report.) Ontario Hydro and its federal counterpart, AECL's CANDU Operations, contain much of the nuclear expertise currently available in Canada. CANDU Operations functions as a fully commercial entity with responsibility for CANDU design work and a mandate to promote the export of CANDU reactors.

While several countries have had small heavy water programs in conjunction with their work on other nuclear systems, Canada is the only advanced industrialized nation that has concentrated its nuclear energy-related R & D almost exclusively on the heavy water reactor. This has permitted a large investment in nuclear power without the need for an expensive fuel cycle or reliance on foreign enrichment and foreign equipment manufacture.

In 1954, the Province of Ontario, through Ontario Hydro, and the federal government, through AECL, jointly undertook feasibility studies towards development of the CANDU nuclear reactor. This work progressed steadily, starting with a small 20 MW demonstrator (NPD, 1958-1962), followed by a 200 MW prototype station (Douglas Point, 1959-1968), and the first large four unit 2,000 MW (4 x 515 MW) commercial station (Pickering A, 1964-1973). The program, supported by sound research and operational feedback, resulted in a nuclear reactor that by the 1970's achieved the highest performance in the world in terms of safety, reliability, and cost.

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[1] Eldorado Nuclear Limited and the Saskatchewan Mining Development Corporation (SMDC) are in the process of being merged prior to their privatization.

Unlike the Light Water Reactor (LWR) program in the United States, which was initially developed for submarine propulsion, CANDU was developed with the objective of providing low-cost electricity as Canada's hydroelectric options became committed and the reliance on coal became both cost and environmentally prohibitive. The CANDU program had the objective of creating a technology that would keep electric power costs low and lead to the development of an indigenous reactor industry, which would in turn develop a market for nuclear equipment and uranium, thus contributing to exports and foreign aid. This led Canada into supplying research reactors to India and Taiwan, and assisting India and Pakistan in starting their nuclear power programs.

Unfortunately, commercial credibility for CANDU came late (mid to late seventies) and only after the Pickering Nuclear Generating Stations (NGS) units 1 and 2 gained operational experience. By then the world market for energy facilities, both thermal and nuclear, was becoming saturated as a result of the slower growth in energy demand brought about by the oil shocks of the 1970s. This late entry into the international energy market by a relatively small player when the demand for energy had already begun to slow posed considerable barriers to the successful marketing of CANDU, although all energy systems faced similar problems at that time.

Ontario Hydro focussed the development of its in-house nuclear expertise on operations, applications engineering, and construction management. The early decision for project management to be utility controlled proved to be a sound basis for Canadian success. Ontario Hydro believes the decision to develop in-house nuclear capability was instrumental in enabling Ontario Hydro to achieve its objective of competitively priced energy.

AECL's original focus was on research, with commercial implementation to be assumed eventually by the private sector. The early thrust was to support Ontario Hydro's nuclear program, followed by those of other Canadian provinces and the overseas market. It took some time for AECL to assume a clear commercial stance on selling CANDU, and by then the immediate market had largely evaporated.

Ontario Hydro had some concern that during the 70's when AECL was engaged in overseas projects in Argentina and Korea and domestic projects in Ontario, Quebec, and New Brunswick, it might not be able to deliver the level of service that Ontario expected. This induced Ontario Hydro to establish a comprehensive design capability to relieve AECL of some of its responsibilities and meet the sequential demands of the Pickering, Bruce, and Darlington nuclear projects. This design capability was in addi-

EXHIBIT XIII.1

HISTORIC RELATIONSHIP BETWEEN REVENUES & CAPITAL COSTS

($ MILLIONS)

Nuclear Projects	Dates of Order	Capital Cost	AECL Revenues	AECL Revenues as a % of Capital Costs
Point Lepreau	1974	1100	95	8.6
Gentilly	1973	1000	76	7.6
Bruce A	1969	1960	106	5.4
Bruce B	1975	5900	174	2.9
Pickering B	1974	3800	88	2.3
Darlington	1978	10900	87	0.8

Source: Atomic Energy of Canada Limited, Candu Operations

tion to Hydro's well established nuclear construction and operating capabilities. The result has been a diminishing management role for AECL in Ontario Hydro nuclear projects (See Exhibit XIII.1).

AECL's Research Company (RC) continues to carry out CANDU-related research, amounting to $125 million per year, and has one of the largest research budgets in the country. Of this total, the CANDU Owners Group (COG), contributes 50 percent of the funding to programs which have a heavy emphasis on safety and fuel channel development and on support to operating stations. The development of new more technically advanced and more economic CANDU designs are largely paid for by AECL. In addition, RC is heavily engaged in spin-off technology development and contract R & D.

The non-energy applications of nuclear technology in Canada include medical treatment, diagnostic services to industry, and research and development in medicine and materials. Much of the national effort in this field has been undertaken by AECL. In particular, AECL's Radiochemical Company (RCC) has established itself as a world leader in the manufacture and production of nuclear isotopes for medical treatment. RCC has a well developed product line with which it is able to command a strong market share in radioactive isotopes for pharmaceutical and diagnostic applications. The company is profitable and is a candidate for privatization by the federal government.

THE DOMESTIC ENERGY MARKET

Nuclear energy was developed initially to provide an alternative to thermal generation of electricity using coal as the fuel. While much hydro potential remains to be developed in Quebec, Labrador, Manitoba, and British Columbia, additional sources of hydroelectricity in the rest of Canada are scarce, comparatively uneconomical, or face other constraints to development.

Coal is therefore the major competition for nuclear generation in the energy field. However, on a total unit energy cost (TUEC) basis, nuclear generating stations demonstrate a more favourable unit energy cost than comparable coal-fired stations.[1] For example, comparing the Pickering nuclear station with the coal-fired facility at Lambton, the costs for operations, maintenance, and administration are much lower for the coal plant, but the nuclear facility enjoys a significant fuel cost advantage. In 1985, for example, Pickering had a TUEC advantage of 27 percent over the Lambton station (See Exhibit XIII.2). This advantage improves considerably with the addition of emission control devices on coal-fired units. Over time, the cost advantage of the CANDU will increase, demonstrating its better resistance to fixed price inflation than that of coal-fired plants.

By adopting nuclear generation of electricity, Ontario Hydro has avoided the purchase of more than $7 billion worth of coal since 1971, over 80 per cent of which would have had to be imported from the United States. This is a significant consideration in light of the concerns about security of energy supply and control over energy resources that surface whenever potential energy investments are examined. Of equal significance is the contribution nuclear generation has made to reducing sulphur dioxide emissions which would otherwise be three times their present level.

Slow growth in the demand for electricity in the early 1980s dampened the requirements for new generating capacity in Canada and created a significant amount of overcapacity in electrical generation. Electricity growth rates during the mid-1970s were about seven percent, and this rate formed the basis for many utilities' expansion plans. However, OPEC price hikes in the '70s resulted in significant investment in energy conservation; this had the effect of lowering the growth in energy demand to three or four percent per year. Any overcapacity that now exists will likely be absorbed by the mid-1990s. Therefore, commitments for new generating capacity will need to be made soon, if they have

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[1] TUEC is the annual cost of producing energy divided by the total energy produced annually.

EXHIBIT XIII.2

COST COMPARISON OF NUCLEAR AND COAL-FIRED STATION
1985

	Total Unit Energy Cost (TUEC) ($/MW·he (net))			
	Pickering NGS-A Units 3 & 4*	Lambton TGS**	Pickering NGS-B***	Coal-fired station with scrubber
Interest, depreciation, and decommissioning	12.07	2.19	35.24	29.77
Operation, maintenance, and administration	6.16	2.52	3.90	3.68
Fueling	4.20	23.32	4.82	23.33
Heavy water upkeep	0.89	—	0.69	—
Total Unit Energy Cost (Net)	23.32	28.03	44.65	56.78
1985 Net energy output (TWhe)	6.2	11.9**	10.9	10.9

* Pickering NGS-A units 1 and 2 did not operate in 1985 due to pressure tube replacement.

** Assumes Lambton TGS also operated as a base load station with Pickering NGS unit 3 and 4 1985 net capacity factor of 68.4%. Lambton TGS actual 1985 net capacity factor was 52.3%.

*** Net capacity factor for Pickering NGS-B and coal-fired station with scrubber was 80.1%.

Source: Ontario Hydro NGD-10, August 1986.

not been already, because of the long lead time required to put that capacity in place.

Ontario accounts for the majority of the confirmed nuclear capacity in Canada, with Quebec and New Brunswick accounting for the remainder. An examination of the domestic energy market indicates that several provinces might offer potential for the future sale of CANDU reactors. These include Ontario, Saskatchewan, Quebec, New Brunswick, and Newfoundland. Whether some or any of these provinces buy CANDUs will be influenced by project economics as well as a number of socio-political considerations, such as the ability to use indigenous uranium resources, the need for energy diversity, the public perception of nuclear power, and the willingness of industry to transfer technological and manufacturing capability to the buying province. For example, in Saskatchewan, although coal-fired (lignite) facilities provide economical energy, a CANDU 300 might also be competitive and would have the benefit of relying on indigenous uranium. Quebec may also be interested in expanding its nuclear base but would probably require a larger portion of the nuclear-related manufacturing to be carried out in the province in order to capture the economic spin-offs from such a project. New Brunswick, with energy circumstances somewhat similar to those of Ontario and an early commitment to nuclear energy, is probably the most likely province to add nuclear capacity.

THE STRUCTURE OF THE NUCLEAR EQUIPMENT INDUSTRY

The Canadian nuclear power equipment manufacturing industry is a high value-added, high technology industry shaped largely by its clients, AECL and Ontario Hydro. The Canadian nuclear power plant industry is made up of a number of subsidiaries of U.S. and U.K. firms, including G.E., Westinghouse, Babcock & Wilcox, and Howden. A few small Canadian companies, such as Donlee Precision and Invar, supply components. Only in a few instances do nuclear sales represent more than ten percent of total sales for any one of the companies involved. This has been a restructuring advantage in a recessionary market as most of the firms can readily survive without the nuclear business.

Many of the nuclear equipment suppliers have developed detailed designs to AECL's performance specifications for specialized equipment, such as steam generators and primary pumps. Some, like G.E. of Canada, have also developed proprietary designs in conjunction with clients for specific components, such as fuel handling equipment. However, AECL itself undertakes much of the proprietary design responsibility for nuclear core equipment.

Marketing efforts by these vendors involve responding to bid requests from AECL for out-of-province projects and Ontario Hydro for Ontario projects. Since all vendors must qualify in advance as acceptable nuclear manufacturers, the evaluation of bids is based on price and delivery factors. The fact that Ontario Hydro and AECL have insisted on competition and second-sourcing of all components and sub-systems has led to duplication and overcapacity within the industry. For example, the calandria can be supplied either by Dominion Bridge/Sulzer or by MIL Vickers and both AECL and G.E. of Canada can design and test nuclear fuelling machines for the CANDU, although AECL does not do any manufacturing. When it appeared that the nuclear industry could expand indefinitely, such duplication of supplies made sense; today, in a limited market, it penalizes all players in the industry.

A CANDU installation consists of two basic parts—the nuclear steam plant (NSP) itself, which generates the steam to turn the turbines that produce the electricity, and the balance of the plant (BOP), which includes the turbines and other equipment, engineering, and project management services necessary to complete the plant. The Canadian content in a typical CANDU 600 amounts to between 85 and 90 percent for projects in Canada and 50 to 60 percent for a turnkey project outside Canada.

The difference between domestic and offshore projects is due to the balance of the plant being sourced from foreign suppliers, in addition to local civil construction work and the installation of mechanical equipment. In arranging the financing for international projects, AECL contracts the BOP from a foreign supplier; this brings in additional financing from the foreign country, thereby reducing the investment risk for the federal Export Development Corporation (EDC). In addition, EDC is often constrained by lending ceilings for a particular country and cannot provide full financing for a nuclear plant by itself. This is not to say that the BOP is not available from Canadian sources; Ontario Hydro purchases the BOP for its projects from Brown Boveri Howden, a Canadian subsidiary of a foreign multinational with the ability to provide BOP with a relatively high Canadian content.

The nuclear steam plant for a CANDU 600 costs approximately $225 million (See Exhibit XIII.3). The value to Canadian suppliers is about $200 million, of which at least 60 percent is sourced in Ontario. Between 1970 and 1987, total CANDU reactor sales gen-

EXHIBIT XIII.3

DISTRIBUTION OF COSTS FOR A TYPICAL CANDU 600 C

	% of Cost	Total Cost ($ Millions)	% of Activity Sourced in Canada	Canadian Content ($ Millions)
• Nuclear Steam Plant (NSP)				
— Equipment	15%	$ 225	90%	$ 203
— Engineering Project Management & Procurement	20	300	100	300
• Fuel & D_2O[1]	11	166	99	165
• Balance of Plant (BOP)				
— Equipment	13	190	40	76
— Engineering Project Management & Procurement	4	57	100	57
• Construction/Installation	37	562	100	562
	100%	$1500	92%	$1363

[1] Continuing cost for fuel and D_2O (heavy water) replacement is about $16M/yr.

Source: AECL.

erated an approximate capital cost stream of $24 billion (See Exhibit XIII.4). Canadian content has amounted to $22 billion, with the NSP and BOP amounting to about $8 billion.

The portion of the nuclear industry that manufactures and supplies components and services for nuclear generating stations is made up of a number of businesses with varying cost structures and competitive dynamics (See Exhibit XIII.5). Some of these nuclear supply businesses operate more or less as subcontractors working for AECL or Ontario Hydro. But in others the CANDU program has special indigenous R & D, related product development, and even non-nuclear export sales.

In most of these supplier business segments, companies spend less than five percent of their sales on R & D. An exception to this is G.E. of Canada, which is investing in the development of better quality fuel bundles for the CANDU. Ontario Hydro represents 80 to 90 percent of the domestic market for nuclear fuels. G.E. of

EXHIBIT XIII.4

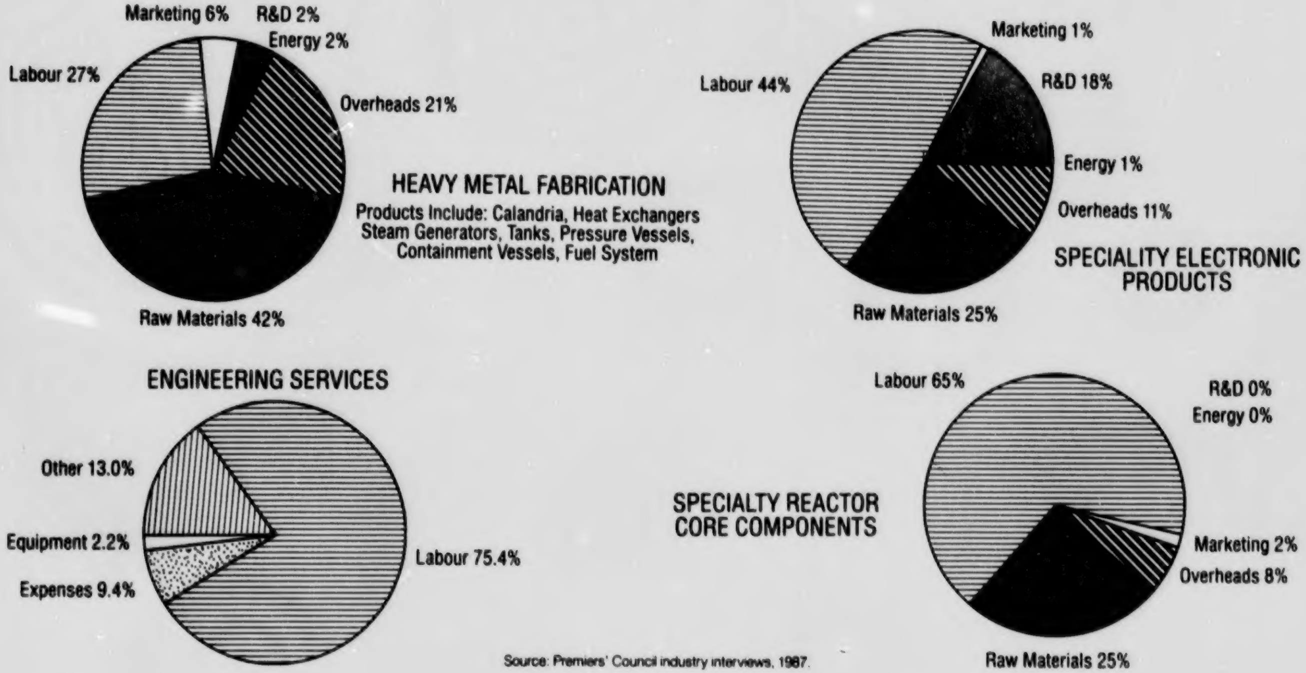
CANADIAN NUCLEAR INDUSTRY SALES 1970-1987
($ Billions)

Reactors	Capital Cost*	Canadian Supplied Content	Manufactured Components (Equipment)
Canada			
Darlington	$10.9	$ 9.8	$1.63
Pickering B	3.8	3.4	0.57
Bruce B	5.9	5.3	0.88
Point Lepreau	1.1	1.0	0.16
Gentilly 2	1.0	0.9	0.15
Romania			
Cernavoda	1.1	0.6	0.16
Korea			
Wolsung	1.1	0.7	0.16
Argentina			
Embalse	1.2	0.7	0.18
TOTALS	$24.1	$22.4	$3.89

*Excluding Interest, Depreciation, and Commissioning.
Source: NGD-10 1985 for Darlington, Pickering & Bruce, AECL for other projects.

EXHIBIT XIII.5

NUCLEAR SUPPLIER INDUSTRY COST STRUCTURES



Source: Premiers' Council industry interviews, 1987.

Canada recognized the opportunity that existed within this limited market and invested $30 million in R & D to improve the quality of its product.

G.E.'s strategy focussed on increasing the concentration of the fuel by applying sophisticated computer technology to reduce the tube wall thickness, increase pellet size, and maintain the tolerances to within 2/10 of 1000th of a millimetre. To gain quality control over the manufacturing of the tubes, G.E. bought the tube manufacturing company. In order to provide assurance regarding fuel stress without incurring metallography costs, G.E. developed an ultrasonic microscope capable of providing a real-time display of the metal structure.

All of this investment resulted in a significant competitive advantage, permitting G.E. of Canada to capture 60 percent of the domestic market and 100 percent of the export market. Westinghouse is now G.E.'s only competitor; Combustion Engineering dropped out of the fuel bundle business in 1986.

Other suppliers investing in R & D include such product areas as electronic control components and turbine and generator sets, which are not specific either to the CANDU or to nuclear reactors but are marketed to the electrical power industry in general.

For example, Velan Inc. has supplied nuclear valves for CANDU reactors for nearly ten years. Through a joint research project with AECL, Velan developed live-loaded packing chambers, which gave it the competitive advantage in the industry. It followed up with another research program that resulted in the development of advanced bellows seal valves, which are used where packing leakage must be eliminated. This product has further improved Velan's international competitive position.

An important spin-off from these private sector nuclear energy R & D investments has been the ability of Canadian companies to compete effectively for export contracts in nuclear and other fields. CAE Electronics Limited entered the nuclear simulator market in 1973 with a contract from Ontario Hydro for the nuclear simulator at Pickering A. Based on its success with this and other simulators, CAE was able to move into the U.S. market in 1984 when it won a contract from Boston Edison. This initial success in the U.S. market was quickly followed by contracts with other U.S. utilities. CAE is now the only company in the world to have been awarded orders for training simulators for all three types of nuclear reactors: heavy water, pressurized water, and boiling water reactors.

Numerous other small companies, including Numet Engineering Limited, Donlee Precision, and NYAB Vicom, have built on the quality control and assurance experience gained in the CANDU program and have moved into manufacturing components for the U.S. aerospace and defence industries.

Technological leadership in the nuclear core lies with AECL. The Research Company invests approximately $125 million annually (federal government contribution plus CANDU owners' organization) in CANDU-related R & D, including waste management. However, little of this money goes towards commercializing the CANDU; that is the responsibility of CANDU Operations, which spends three to ten percent of its revenues on product engineering and commercialization.

The nuclear power equipment industry has undergone some rationalization during the recent recession. A number of key component vendors, including Chase Nuclear (pressure tubes), Standard Modern (fuelling machines), and Byron Jackson (pumps), have merged with other suppliers or dropped out of the business, thereby reducing some of the duplication in the industry. It is expected that AECL's program of pre-selecting key component manufacturers will help protect the manufacturing base from shrinking too far.

At the same time, one manufacturer indicated that the lack of a clear rationalization plan has frozen his investment plans in such technologies as CAD/CAM and advanced manufacturing systems. There is also some concern that the current restructuring alone will not be sufficient to sustain the industry and protect the manufacturing technology base. It was this concern that prompted Ontario Hydro to launch a security of supply program to protect its $30 billion investment in existing nuclear plant and facilities. Its secondary objective is to maintain the capability to deliver a new plant. For many manufacturers, the time lag between orders has placed them in a restart situation, forcing them to attach a premium to the next order, particularly if it does not form part of a long-term commitment to nuclear equipment.

OTHER NUCLEAR BUSINESSES

Nuclear Research and Servicing

The RC manages two major research sites: Chalk River, Ontario, and Whiteshell, Manitoba. While close to 30 percent of the RC's expenditures is devoted to CANDU reactor development, considerable emphasis is also placed on developing new technologies (See Exhibit XIII.6). Over the years the RC has developed a number of proprietary products for specific market segments. They range from such items as a radiation bubble detector, electron-accelerators and eddy current probes, to local energy systems, research reactors, and special high-tech instruments like the ferroscan, which measures and monitors wear in machine

EXHIBIT XIII.6

AECL RESEARCH COMPANY PROGRAM EXPENDITURES
1987-88

	$ Millions	% of Total
CANDU Reactor Development	$ 74.0	29.2
Waste Management	$ 49.0	19.4
Physics and Health Sciences	$ 31.0	12.3
Radiation Applications and Isotopes	$ 12.0	4.7
Business Development	$ 20.0	7.9
Commercial Activities	$ 29.0	11.5
NPD/Townsite (net)	$ 7.0	2.8
Capital	$ 31.0	12.2
Totals	$253.0	100.0%

Source: Atomic Energy of Canada Limited, 1987.

parts. Several of these technologies have already been spun off by the RC into revenue generating businesses. Primary circuit pump seals, originally developed for the CANDU reactor, are now being supplied to utilities in the United States, and the company recently won a contract to develop a seal material for the space shuttle booster sections.

AECL's Engineering Services Branch is beginning to tap into the extremely lucrative and intensely competitive nuclear engineering services business. The non-CANDU nuclear services market, estimated at $5 billion per year, is centred in the United States, where many of the nuclear utilities are smaller and have less in-house technical capability, and therefore contract out for more services. Ultimate success in this business will most likely require establishing a U.S. identity and undertaking joint ventures with U.S. companies.

One successful Canadian nuclear spin-off, London Nuclear, may point to the type of opportunities available in these spin-off markets. Unfortunately, the company is shifting its activities more into the U.S. due to better market opportunities.

London Nuclear was spun off from a joint R & D program undertaken by AECL and Ontario Hydro in the area of nuclear servicing. Originally CAN-DECON technology was developed in the early 1970s to decontaminate Ontario Hydro's CANDU reactors. In 1977, W.P. London & Associates received a licence to market the technology; at the same time key AECL employees were transferred to the new company.

London Nuclear Decontamination became quite successful and captured 70 percent of the North American market. Competitors included G.E., Westinghouse, Combustion Engineering, Pacific Nuclear, and Bechtel.

London Nuclear's competitive advantages included timing (it was the first in the business) and its relationship with AECL and the Ontario Research Foundation, which gave it a strong technical base and support in marketing of the product. Later, London Nuclear developed a number of international relationships through licensing with Framatome in France and Kurita Water Industries in Japan and engaged agents in Korea, Taiwan, Sweden, Finland, Belgium, and Italy.

In the early 1980s the CAN-DECON process came under severe criticism, and London Nuclear lost its strong market position. Several U.S. utilities charged that the chemicals used in the process initiated stress corrosion cracking in LWR materials. London Nuclear embarked upon an R & D program in 1984 that overcame problems in the process. Nevertheless, corporate and process credibility had to be re-established.

At about the same time, a new decontamination technology, the LOMI process, was developed in the U.K. In 1984 London Nuclear became one of a number of licensees of this process. Once again the company's competitive advantage arose from an agreement with Davy McKee Nuclear (U.K.), giving it access to technical support from scientists who had developed the process.

In 1985, London Nuclear was awarded all of the LOMI business in the United States and regained strong market share. In addition, the credibility of CAN-DECON has been re-established for use in LWR's and it now accounts for 40 percent of the company's decontamination business.

Nuclear Medicine and Radiation Processing

The RCC develops, produces, and sells products, equipment, and services to medical and industrial diagnostic and irradiation markets around the world. Its two main businesses are nuclear medicine and radiation processing. In 1986, the company employed about 360 highly skilled people (labour represents 18 percent of the cost of sales), primarily in Kanata, Ontario, with some in Vancouver. Over the last few years, revenues have doubled while net income has tripled, resulting in an extremely profitable business. In 1986-87 revenues were $86 million, about 75 percent of which came from exports. Radiation processing accounted for $53 million in revenues, while nuclear medicine accounted for the remainder. The company operates as an independent commercial entity and receives no government grants.

The nuclear medicine business can be divided into two distinct segments, bulk reactor isotopes and radiopharmaceuticals. The bulk reactor isotope business involves the use of radioactive chemicals to manufacture radiopharmaceuticals, labelled compounds or sources for nuclear medicine, research, and industry applications. This is a mature business, accounting for 70 percent of the revenues of the nuclear medicine division, with 90 percent of the product going for export.

The manufacture of radiopharmaceuticals is a recently established business; value-added products derived from radioactive chemicals are used for medical diagnoses and, occasionally, for therapy. Products include technetium-99M (general imaging and diagnostics), carbon-14 (labelled components), iodine-125 (bone imaging), iodine-123 (general diagnostic and imaging applications), and xenon-133 (lung perfusion studies). The RCC is a major supplier to nuclear medicine departments in 150 Canadian hospitals, and market growth is anticipated at six percent. The market is extremely competitive and price-sensitive, and a key strategy in the nuclear medicine business is therefore to generate new radiopharmaceuticals to broaden the product line.

The radiation processing business includes the irradiation of disposable medical products, food and waste, development of cobalt sources, and the supply of clinical, research, and educational irradiators. The irradiation of disposable medical products represents 80 percent of the company's total business and more than half the world market. Significant growth in revenues (ten percent per year) is anticipated in the United States, Western Europe, and Japan as a result of the decline in the use of competing chemical technologies. Waste treatment and other secondary and tertiary treatment applications are currently generating minimal revenues. This could change depending upon environmental priorities. Cobalt sources, research, clinical, and educational irradiators make a minimal contribution to revenues and represent a mature market. The irradiation of food could develop significantly, depending upon regulatory and public acceptance.

The RCC's competitive advantage in international markets lies in its complete systems approach to radiation processing, combined with an abundant supply of low cost cobalt. There are no proprietary products or processes in the irradiation business. To remain competitive, the company must emphasize product improvement and cost reductions. Key technologies include

Cobalt-60 production technology, materials, knowledge of automated systems, and nuclear physics. Raw material cost is a major competitive factor in this business. Canada's advantage is that it is a leader in the production of large supplies of cost-competitive Cobalt-60 through Ontario Hydro's CANDU reactors.

Food irradiation, one portion of the radiation processing business, is a process of killing micro-organisms by exposing food to ionizing energy, such as gamma waves or x-rays. It offers a number of food handling and storage benefits, such as increased shelf life and reduced spoilage; for example, fresh irradiated poultry can be kept refrigerated in the home for as long as seven days, as opposed to three days for non-irradiated poultry. Irradiation is not suitable for all foods and cannot be used to make an inferior product better, but it has demonstrated advantages over chemical fumigants and preserving agents. The most notable are that it leaves no residue, it penetrates foods to kill pests that have reached the interior, and it can be applied after food has been packaged, thus preventing reinfection.

The 1984 continent-wide banning of ethylene dibromide as a fumigant in the food industry raised questions about the use of other chemical fumigants and additives and encouraged government and industry to look for alternatives. Irradiation has an established track record in replacing chemicals used in medical sterilization and was therefore given serious consideration. In 1983 the United Nations Codex Alimentarius Committee set standards for the irradiation of foods and ruled that foods processed to these standards retain their wholesomeness. The committee has representation from 125 countries, and its standards provide a foundation for national regulations. As a result, there has been increasing commercial production of irradiated foods in Europe, the Far East, and the Third World. Several groups in the United States and Canada oppose food irradiation, questioning the economics of the process and calling for further studies on the wholesomeness and nutrient value of irradiated food, even though the process has been declared safe by a number of international organizations and by Health and Welfare Canada. Canadian and U.S. acceptance of food irradiation is the key to further international acceptance of the process.

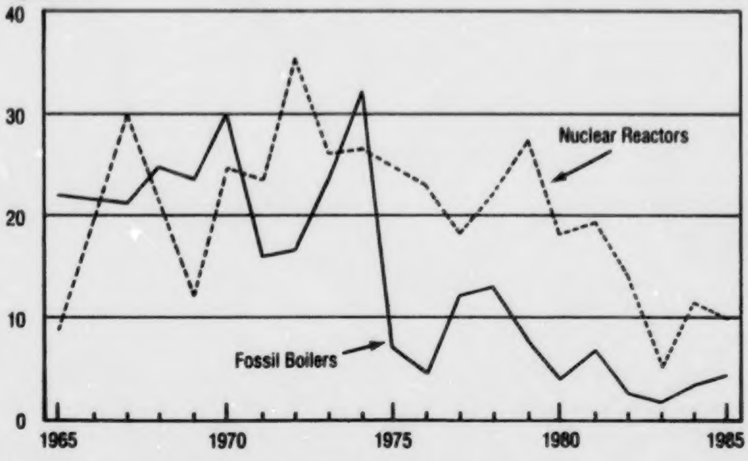
THE INTERNATIONAL ENERGY MARKET

Many consider nuclear energy an emerging technology, and recent work examining the life cycle of energy systems places nuclear energy in its infancy. With little more than a four percent share of the world's commercial primary energy market in 1985, it is predicted that nuclear energy's market share will grow to more than 50 percent of the market by the end of the next century. After that, its market share would decline until the end of its life cycle, early in the twenty-second century. This optimistic projection of the future of nuclear energy belies its current difficulties, however.

Although worldwide nuclear electric power generation has increased steadily, pre-1984 forecasts were overly optimistic. A period of low growth in electricity demand (1975-1983) led to a dearth of new orders for electricity generating plants of any kind, with particularly serious consequences to the rapidly developing nuclear industry (See Exhibit XIII.7). The decline in sales resulted in low utilization rates in the manufacturing sector, creating fierce competition for international projects. The international market has become even more difficult because raising large project financing is increasingly problematic, especially for emerging nations.

EXHIBIT XIII.7

WORLDWIDE ORDERS FOR ELECTRIC POWER GENERATING EQUIPMENT



Source: Kidder, Peabody & Co. Inc.

Profile of the Competition

AECL/CANDU's serious international competitors include Framatome, KWU, Westinghouse, and Combustion Engineering, all of which market light water reactor technology. AECL/CANDU has been able to capture only about six per cent of the world power reactor market (See Exhibit XIII.8), in part because the original objectives of the CANDU program placed exports behind domestic needs. Timing and, in particular, the delayed completion of early prototypes relegated CANDU to a late entry status behind the LWR programs of Westinghouse, G.E., and other U.S. vendors.

Confidence in American technology led many of the large utilities in the U.S. to place their orders for nuclear reactors on the basis of expectations alone. Unfortunately, CANDU enjoyed no such leap in faith and had to establish a track record based on operating experience. When its performance was finally proven in the mid-70s, the market was not as healthy and most countries were already partial to the LWR.

Even so, one could speculate that AECL could have offered fixed-price contracts to U.S. utilities in the late '60s, when U.S. vendors were no longer willing to offer these terms. U.S. utilities were still convinced of the cost-effectiveness of their nuclear investments. A lack of entrepreneurial spirit, combined with an inability to guarantee the supply and price of heavy water, are often cited as the reasons that AECL missed an opportunity to export early in the program. It should be recognized, however, that there were significent obstacles to exporting. These included U.S. licensing requirements and utility industry protectionism.

Nuclear vendors such as Framatome, KWU, Westinghouse, and Combustion Engineering continue to invest in product R & D to reduce system complexity, component, and construction costs while maintaining high safety standards and reliable plant operations. Doing so requires all systems and components to be of the very best design and technology available. This demand for extremely high reliability makes direct salary and labour costs much higher for nuclear than for non-nuclear energy facilities. Consequently, the industry is faced with carrying the high overhead costs associated with the skilled personnel necessary to execute a nuclear project. Competition among vendors then focusses on the amount of labour required to build a plant.

Framatome offers a good example of the kinds of strategies these foreign suppliers have followed. Framatome began in the early 1970s as a Westinghouse licensee for pressurized water reactors (PWR). By 1972 it had its own nuclear component production factories and became widely connected with a large num-

EXHIBIT XIII.8

NUCLEAR REACTOR VENDORS

Company	Ownership	Units Ordered	% of Market	Cumulative GWe
AECL	State	32	5.3	19.4
Combustion Engineering	Private	16	2.6	15.3
Framatome	State & Private	64	10.5	65.8
GE	Private	70	11.5	54.3
KWU	Private	36	5.9	34.3
Westinghouse	Private	86	14.1	74.1
Other[1]		305	50.1	192.0
		609	100.0	455.2

[1] Other includes: Mitsubishi (17), Toshiba (10), Hitachi (7), AESA-Atom (12), India (10), U.K. (44), USSR (150), Skoda (14), Bascock and Wilcox (13), and miscellaneous (28).

Source: Kidder, Peabody & Company Incorporated, Status Report on nuclear reactors worldwide as of December 1986.

ber of French companies through ownership or consortia. In 1974, it was selected as the exclusive producer for the French domestic market and added a strong political linkage to its already well established industry linkages. By standardizing units and selling those units abroad as a low-cost producer, it looked as if it would be able to lower production costs. Framatome focussed its engineering efforts on cost reduction based on a production rate of six units per year.

However, the downturn in energy demand afflicting most vendors has not spared Framatome. By the mid-1980s it was receiving only one domestic order per year, and even these were not really needed by France. Electricite de France (EDF) was closing down modern coal-fired stations and subsidizing the consumption of electricity. Nevertheless, France has successfully articulated a firm business strategy and appears to be prepared to implement it regardless of the competition. If nothing else, France has achieved a unity of purpose that as yet has escaped most other nations. Clearly, France wants to be in the nuclear business for the long term.

Factors Influencing System Selection

The decision to build a nuclear power plant is complex. Price is only one of the many factors to be considered and it may not be the most important one. The availability of sufficient and acceptable financing, for example, is an essential factor in any decision to purchase a reactor, and the inability of the vendor country to arrange a large loan with long-term credits can be a major impediment to a reactor sale. The current environment for international finance is particularly turbulent because of the debt situation of developing countries. Any vendor who can put together a financing package using countertrade or equity financing will gain an advantage in the marketplace. However, unless it is sourced globally, equity financing is a poor approach for Canada because it lacks the financial resources of the countries that are its major competitors.

CANDU reactors have an international reputation for technical excellence and reliability. Their fuel cycle independence is particularly important for countries with indigenous uranium or thorium resources, such as Turkey. The major concern of CANDU customers is the longevity of the technology offered by AECL, which has a relatively small share of the market relative to light water reactors. Even though AECL is thought to have weak linkages with the Canadian nuclear industry, both have considerable experience in transferring technology, and this is perceived by the market as a competitive advantage. However, competing vendor countries such as the United States, France, and West Germany normally have stronger trading relationships and greater political leverage with the potential markets.

Canada's philosophical approach to regulating nuclear reactors differs substantially from that of other countries, particularly the United States. The early domination of the market by the United States led many countries to model their regulatory processes after the U.S. process. In some markets this is an impediment to the introduction of CANDU. However, some of the joint R & D activity between AECL and Japanese interests is examining the issue of whether CANDU could be licensed within a regulatory environment set up to govern the use of light water reactors.

Japan's Interest in the CANDU

The Japanese are extremely interested in acquiring heavy water technology and over the last ten years have paid about $30 million to AECL in support of CANDU-related design and development. The basis for this interest is CANDU's economic performance, fuel-cycle efficiency, and flexibility. The CANDU appears to require only minor design modifications to conform to Japanese guidelines and standards.

The Japanese believe that the CANDU, because of its fuel flexibility, can play a significant role in extending the Japanese fuel cycle. CANDU offers high resource utilization efficiency for a variety of fuels, resulting in significant uranium savings. Since Japan is totally dependent on imported fuel, the CANDU can contribute to its future energy security.

The purchase of an LWR system is considered by some as an implicit commitment to the fast breeder reactor (FBR). The argument is that FBRs will become necessary because at some point in the next century, the supply of low-cost, accessible uranium will decline and technological advances will permit the economic recycling of used fuel from LWRs. An FBR would use the plutonium in the spent fuel, amplifying a low-cost uranium resource by a factor of 50.

To date, FBR technology has proved expensive and difficult to commercialize. Both France and West Germany are encountering difficulties in starting up their FBRs. The Japanese are sufficiently concerned that they have delayed the in-service date of their first commercial FBR until the year 2020. They believe that the CANDU will fill their need for a technology that will not only bridge the LWR-FBR gap but also allow them to extend it.

CANDU MARKET SHARE AND FUTURE OPPORTUNITIES

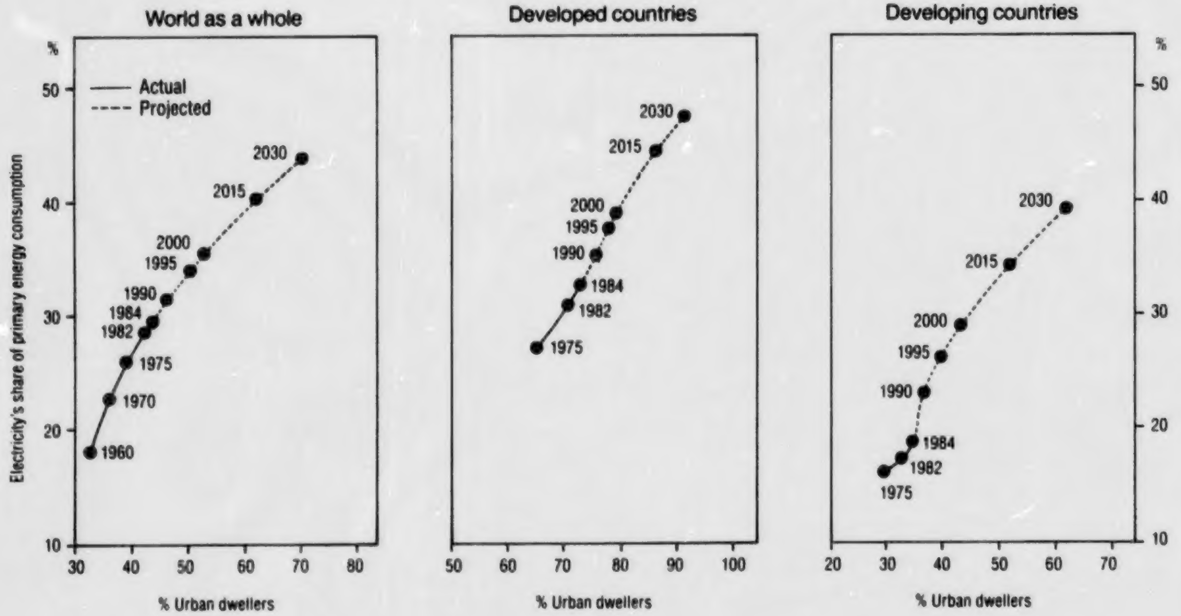
Primary energy consumption in developing countries has been increasing as the population moves from rural to urban environments (See Exhibit XIII.9), and as urbanization increases, so does electricity's share of primary energy consumption. Over the last 85 years electricity has been making inroads into the global primary energy market. Within the last 25 years, nuclear energy has become the second largest contributor to electricity generation in the OECD. In 1985, Belgium, West Germany, Japan, Spain, and Switzerland reported more than a 20 percent increase in nuclear power generation. In France and Belgium, the nuclear contribution was well over 50 percent of the total electricity generated.

The existing international market for nuclear power reactors is presented in Exhibit XIII.10. The size of the market is about 400 GW, of which CANDU represents between five and six percent. This market is divided into nuclear vendor countries, representing about 80 percent of the market, and non-vendor countries, representing the remainder. Except for the Canadian domestic market, the nuclear vendor country segment has been closed to CANDU, limiting this market's contribution to CANDU's global market share to 3.9 percent. The non-vendor country market segment contributed an additional 1.6 percent of CANDU's world market share. However, since this non-vendor country segment is only 20 percent of the total, CANDU's market share in this segment alone is effectively eight percent. The non-vendor country segment is further subdivided into those countries that have received ministerial approval for the export of nuclear technology and those for which approval has not yet been granted. This latter group includes Argentina, India, and Pakistan, countries that have already acquired CANDU technology. Within the non-vendor country segment, CANDU's market share in the group of countries that already have ministerial approval amounts to about 22 percent and about four percent in the group that does not yet have approval. From another perspective, CANDU has 100 percent of the domestic market and 22 percent of its accessible market overseas.

AECL has projected future opportunities for sales of nuclear power reactors in the global market by examining the key factors that determine a country's ability to support a nuclear program. Capability is measured by the size of the country's electricity grid, which indicates the country's ability to absorb further additions to capacity and the sophistication of the system. Affordability is measured by total GNP, which indicates a country's financial ability to pay back a large investment over time. Capability and affordability establish a basic threshold of ability to support

EXHIBIT XIII.9

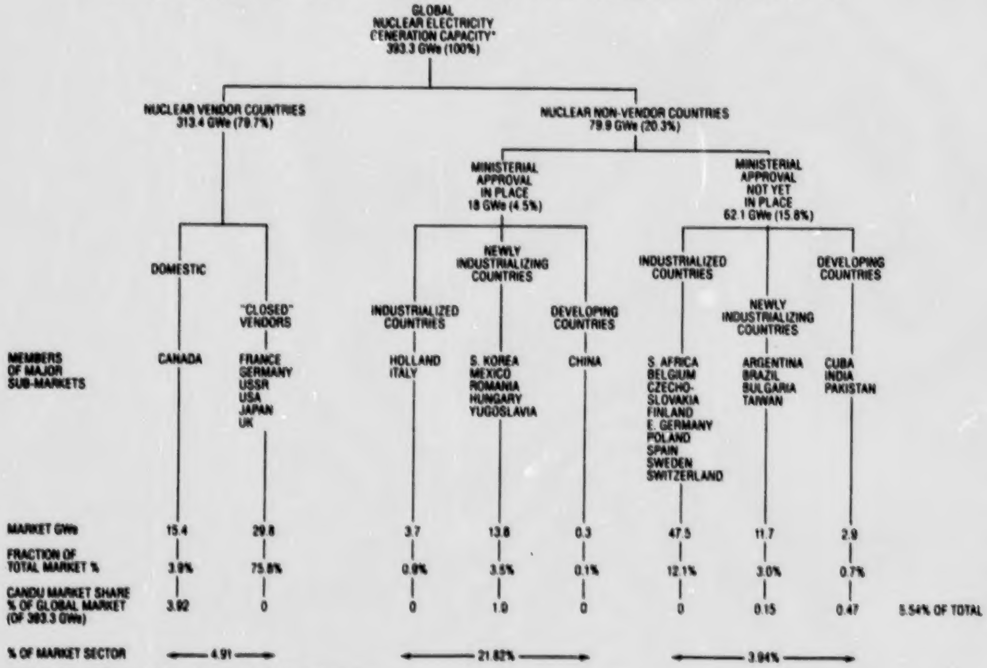
WORLD ELECTRIFICATION AND URBANIZATION TRENDS



Source AECL/U.N. Statistics & Extrapolations

EXHIBIT XIII.10

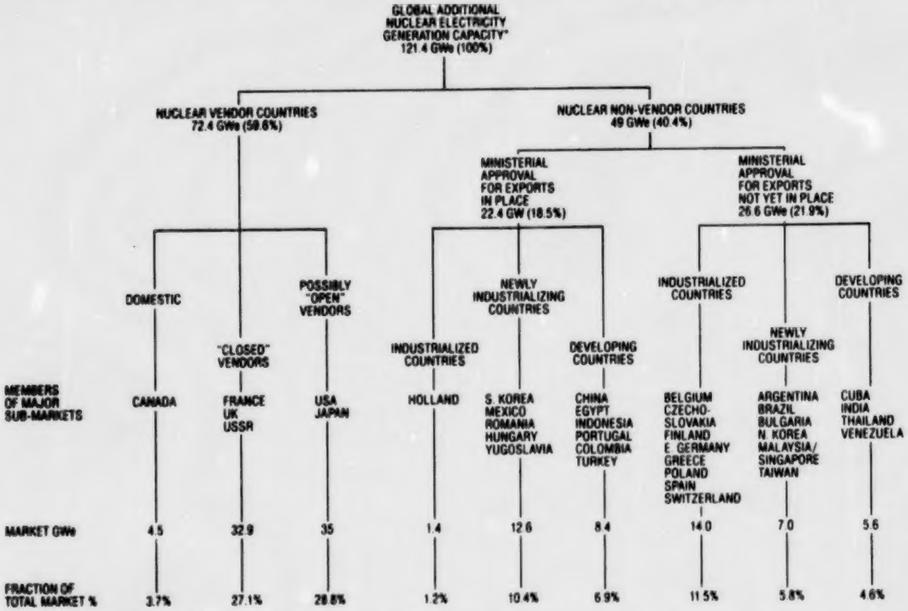
THE DEVELOPED GLOBAL MARKET FOR NUCLEAR POWER REACTORS TODAY AS MEASURED BY REACTOR CAPACITY OPERATING AND UNDER CONSTRUCTION


GLOBAL NUCLEAR ELECTRICITY GENERATION CAPACITY* 393.3 GWe (100%)
NUCLEAR VENDOR COUNTRIES 313.4 GWe (79.7%)
NUCLEAR NON-VENDOR COUNTRIES 79.9 GWe (20.3%)
MINISTERIAL APPROVAL IN PLACE 18 GWe (4.5%)
MINISTERIAL APPROVAL NOT YET IN PLACE 62.1 GWe (15.8%)
DOMESTIC
"CLOSED" VENDORS
INDUSTRIALIZED COUNTRIES
NEWLY INDUSTRIALIZING COUNTRIES
DEVELOPING COUNTRIES
INDUSTRIALIZED COUNTRIES
NEWLY INDUSTRIALIZING COUNTRIES
DEVELOPING COUNTRIES
MEMBERS OF MAJOR SUB-MARKETS
CANADA
FRANCE GERMANY USSR USA JAPAN UK
HOLLAND ITALY
S. KOREA MEXICO ROMANIA HUNGARY YUGOSLAVIA
CHINA
S. AFRICA BELGIUM CZECHO-SLOVAKIA FINLAND E. GERMANY POLAND SPAIN SWEDEN SWITZERLAND
ARGENTINA BRAZIL BULGARIA TAIWAN
CUBA INDIA PAKISTAN
MARKET GWe
15.4
29.8
3.7
13.8
0.3
47.5
11.7
2.9
FRACTION OF TOTAL MARKET %
3.9%
75.8%
0.9%
3.5%
0.1%
12.1%
3.0%
0.7%
CANDU MARKET SHARE % OF GLOBAL MARKET (OF 393.3 GWe)
3.92
0
0
1.0
0
0
0.15
0.47
5.54% OF TOTAL
% OF MARKET SECTOR
4.91
21.82%
3.94%

Source: Atomic Energy of Canada Limited, CANDU Operations.

EXHIBIT XIII.11

PROJECTED LONGER-TERM GLOBAL POWER REACTOR MARKET TO 2000



Note: New orders to approximately the vision period midpoint (CANDU Operations VERY LOW projection, November 1987)

* Cumulative new orders for nuclear capacity to the end of the year 2000 (above and beyond the 250 GWe in service and the 140 GWe under construction, at end of 1986)

Source: Atomic Energy of Canada Limited, CANDU Operations a nuclear program; a country's score on the basic capability/affordability evaluation is then tempered by considering the availability and diversity of local energy resources, weighted on the basis of the availability of uranium and thorium, and modified according to socio-political considerations influencing the country's propensity toward nuclear technology. Using this evaluation method, AECL identified 54 countries that met the criteria and another 23 countries most likely to meet the criteria in the future.

On the basis of this type of evaluation, which produces a "very low" projection of future opportunities (See Exhibit XIII.11), the market for nuclear power as measured by new orders by the end of the year 2000, amounts to 121 GW, as compared to 400 GW, the approximate size of the current committed base. The sector that includes vendor countries represents 60 percent of the total market (compared to 80 percent today) while the non-vendor sector represents 40 percent (compared to 20 percent today).

In this "very low" projection, at least 45 of the 77 countries representing 80 percent of the world population are assumed to place new reactor orders during the 30-year period between 1988 and 2017. With the proven CANDU 600 and new low cost products, the smaller CANDU 300 and the larger CANDU 1200, and with a focus on selected market niches where CANDU advantages can be capitalized on, AECL projects CANDU market share at 13 percent, compared to 5.5 percent today.

Currently, AECL markets the CANDU 600 internationally as a field-proven reactor. However, it believes that a market is developing for a smaller reactor to satisfy the needs of regions with smaller grids or major population centres distant from available electricity sources. Consequently, it has begun to develop the CANDU 300, which is being designed as a standardized, low cost, reactor as a means of achieving a dominant position in selected markets in Canada and abroad. In addition to the CANDU 300 and 600, there is a potential opportunity to develop a CANDU 1200.

In Japan, EPDC has indicated an interest in scaling up the CANDU 600 to 1200 MW and in introducing this unit into Japan after the initial introduction of the CANDU 600. Such a unit could be of interest to Ontario Hydro, given that major segments of the population, elected representatives and review agencies such as the Ontario Energy Board, are concerned about Ontario Hydro's apparent over-commitment to nuclear power, especially in light of the current supply and demand situation. A key concern is the large financial commitment involved in developing a four-unit station such as Darlington. Such a large commitment of funds may not be politically acceptable in the future.

Though much can be done to defer plant orders for several years—through electricity imports, rehabilitation of fossil-fueled units, and conservation—capacity additions of up to 1000 MW will be necessary. To satisfy this requirement, it might be possible to develop a single 1200 MW CANDU station, using standard components and systems, that could match the per-kilowatt capital cost of a four-unit station.

Assuming that the CANDU cost can be reduced through technology advances now in hand at AECL, this could result in a 1200 MW unit with energy costs in the future that are very competitive with those of a multi-unit station. This would allow Ontario Hydro to undertake fully standardized single-unit 1200 MW stations, each representing a fraction of the commitment required for large multi-unit stations, with better response to demand. This could be even more advantageous if pre-licensing of designs and sites became common practice.

With potential applications in both Japan and Ontario, a three-way Ontario Hydro/EPDC/AECL arrangement for the development of the CANDU 1200 MW might have some appeal and make good business sense. At the other end of the spectrum, the smaller CANDU 300 standardized station could be attractive from the point of view of such criteria as regional development, remote siting, and electric grid considerations.

POLICY ISSUES

The fate of CANDU is open to speculation, and the Canadian nuclear industry continues to pose a number of critical choices for Ontario and Canada. These choices revolve around a number of key issues:

- How to sustain design and marketing capabilities in a depressed market
- How to adjust and sustain manufacturing capabilities at a lower level of demand
- How to expand the industry's private sector base and find a more effective distribution of industrial and technological responsibility between the public and private sectors
- How to orient the Canadian nuclear effort more towards international opportunities
- How to use diversification, international project development, and the advancement of Ontario Hydro's programs as vehicles to sustain the domestic nuclear capability.

Any decision regarding these choices must recognize the importance of AECL and Ontario Hydro, as well as the rest of the nuclear industry, in assuring the health of CANDU for the future. Much of the analysis, discussion, and research on the nuclear industry has indicated that Canada has developed a respectable technology but has not been decisive in its implementation. This is largely because the industry has not developed strong political linkages in the country, resulting in an ill-defined and often unclear mandate. It is not clear whether Canada wants to be a nuclear vendor. This indecisiveness has frustrated any attempt to develop a successful commercial strategy.

Decisions regarding nuclear energy and technology are always socially and politically sensitive. Nevertheless, if the industry is to come to grips with these issues, it will require a clear definition of industry objectives, a more focussed deployment of resources, and a concerted effort on the part of all participants to identify and meet the demands of the international marketplace.

SPECIAL STUDIES

CHAPTER XIV

ONTARIO START-UP COMPANIES AND THE VENTURE CAPITAL INDUSTRY

The phenomenon of rapid economic growth through new business creation has been studied in depth at locations that have become famous for it, including Silicon Valley, Boston's Route 128, and Cambridge, England. The success rate of firms in these regions and the economic prosperity they produce has aroused considerable interest in the question of how do these businesses start and how can their success rate be maximized. Successful start-up companies today will provide the pool of firms which can become the threshold companies of tomorrow. Consequently, governments around the world are seeking ways to promote a healthy entrepreneurial culture. Ontario is no exception.

Start-up companies are an important source of continued revitalization in any economy. New goods and services are often the product of recently established businesses. The many innovative products introduced by thousands of small businesses every year provide one of the spurs that keeps leading companies constantly updating existing products. New markets often begin as small niche markets suited to new businesses but not yet attractive to established firms.

Small businesses—many of which are new businesses—also account for the bulk of new job creation in the economy. In Canada, businesses with fewer than 20 employees account for at least 55 percent of net employment growth (See Exhibit XIV.1). Although new businesses are unquestionably the source of many new jobs, their role may be somewhat overstated because this volatile sector of the economy also has the highest bankruptcy rate. Firms with fewer than five employees have been found to have a 41 percent "death rate" and firms with six to 20 employees, a 20 percent death rate (See Exhibits XIV.2 and XIV.3). Given the rapid rate of business creation and dissolution among small businesses, many of the new jobs may not be lasting ones. For example, a new restaurant may create 20 new jobs, but if the restaurant does not succeed, another 20 jobs may be "created" by another restaurant taking its place.

To understand the entrepreneurial sector of the Ontario economy, the Premier's Council surveyed Ontario companies estab-

EXHIBIT XIV.1

CONTRIBUTION TO NET EMPLOYMENT GROWTH BY ENTERPRISE SIZE

Number of Employees	Contribution to Net Employment Growth
Fewer than 20 employees	55.0%
20–49	9.0%
50–99	0.6%
100–199	−2.0%
200–499	−1.6%
500+	39.0%
Total	100.0%

Source: *A Study of Job Creation in Canada*, DRIE.

EXHIBIT XIV.2

BIRTHS AND DEATHS OF NEW COMPANIES IN CANADA 1978–1982

Number of firms, 1978	596,429	
Gone out of business ("deaths"), 1978–1982*	211,583	(35%)
Remained active, 1978–1982	384,846	(65%)
New companies formed, 1978–1982	327,167	(55%)
Net number of companies, 1982	712,013	
Proportion of firms in 1982 that existed in 1978	54%	

*This figure includes companies that have been acquired or merged and some instances where the company name and payroll deduction number changed.

Source: Statistics Canada T4 Data Base Analysis of Job Creation, DRIE.

lished since 1979. Companies were selected from manufacturing and traded service businesses, particularly those in higher value-added and technology-intensive sectors. The survey results provide a snapshot of the environment in which these Ontario

EXHIBIT XIV.3

DEATH RATE OF FIRMS, BREAKDOWN BY SIZE OF COMPANY

Number of Employees In Firm	Distribution of Firms 1978	Total Number of Firms 1978	Number of Deaths 1978–82	Death Rate Within Size Category 1978–82
Less than 5	75%	449,393	184,815	41%
5–19	18%	103,561	20,704	20%
20–49	5%	26,003	4,058	16%
50–99	1%	8,766	1,237	14%
100–499	1%	6,935	699	10%
500+	–	1,771	70	4%
Total	100%	596,429	211,583	

Source: Statistics Canada T4 Data Base Analysis of Job Creation, DRIE.

companies operate, as well as suggesting reasons for their success or failure.

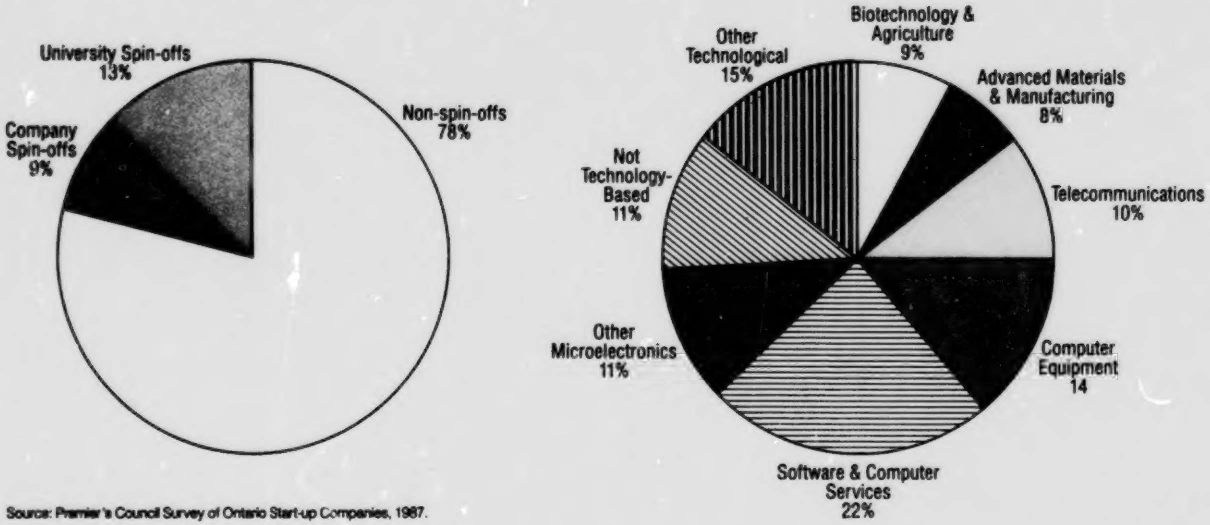
The survey was carried out by The Canada Consulting Group, Telesis, and the Ministry of Industry, Trade and Technology personnel. Personal interviews were conducted in 71 companies, in most cases with one or more of the founding entrepreneurs. Names of companies interviewed were drawn from:

- Lists of companies provided by Innovation Ontario, Ontario Development Corporation, and the Ontario Technology Centres
- The MITT database of Ontario manufacturing companies, selected by starting date and level of exports
- Members of the Canadian Advanced Technology Association
- University spin-off companies
- Spin-offs of companies interviewed as part of other research on behalf of the Council
- Other industry associations and contacts.

The companies selected were founded between 1979 and 1986 and represent a broad range of business types and industries from telecommunications to biotechnology, auto parts manufacturers, and fashion design houses (See Exhibit XIV.4). A subset of firms

EXHIBIT XIV.4

DISTRIBUTION OF THE COMPANIES PARTICIPATING IN THE PREMIER'S COUNCIL START-UP SURVEY



COMPANY TYPE

INDUSTRY

Source: Premier's Council Survey of Ontario Start-up Companies, 1987.

that provided at least four years of sales history was also developed. These were then grouped into three categories to analyze reasons for their relative success or failure:

Category One—Exceptional Companies

- Seven companies in the survey were well-established, and their annual sales in the first four years of business were greater than $2,500,000.

Category Two—Growing Companies

- Eleven companies selected from the survey had average annual sales in their first four years of between $800,000 and $2,000,000.

Category Three—Struggling Companies

- Nine companies were selected from the survey with average annual sales in their first four years of less than $800,000.

SURVEY FINDINGS

Conclusions and recommendations arising from the survey were presented in Chapter VII of Volume I of the Council's report. The purpose of this chapter is to review the survey findings and to examine other research into the nature of successful entrepreneurial cultures.

The survey conducted for the Premier's Council examined several aspects of Ontario start-up companies:

- **Origins**—the background of the founders, the original idea for the business, and the source of the key technology used
- **The Business Challenge**—marketing, R & D, financing, and making the transitions from a service to a product and from a technological advantage to a competitive advantage in the marketplace
- **Interaction with Government and Universities**—public sector institutions, government assistance programs and government procurement policies
- **A Case Study of Spin-off Companies**—interviews with former Northern Telecom and Bell Northern Research employees who started their own companies.

Origins

One of the most striking conclusions about the origins of the 184 entrepreneurs interviewed (who started a total of 71 companies) was that about half of them had previously founded other companies. Sixty percent of those other companies are still in operation. The profile that emerged, particularly among the technology entrepreneurs, was of a relatively small, closely linked community of highly trained and motivated individuals who form alliances to pursue new ventures. A few years after an alliance is formed, it may be dissolved and new alliances formed to pursue the next technological breakthrough.

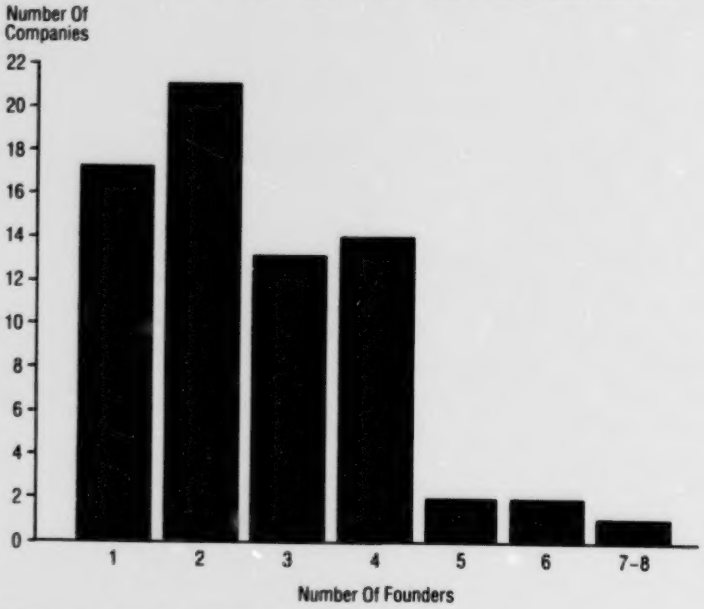
For example, a group of graduate students at Queen's University was involved in text retrieval systems work led by a professor who founded Q.L. Systems. In 1976, two of these students left Queen's to form their own company, Mobias, to carry out custom software work for an American firm, Westlaw Publishing. Their text retrieval software company grew to 40 employees by 1981. Mobias was then acquired by an Ottawa entrepreneur and became part of the Nabu Network. When Nabu folded in 1983, some of the Mobias partners joined with Nabu colleagues to form a new company, Fulcrum. Fulcrum is also in the full text library retrieval systems market, but this time with a software product rather than as a contract service business. As Fulcrum managers put it, "Companies come and go but the accumulated expertise isn't lost. Fulcrum is a much stronger company than Mobias was because we added marketing expertise (people) that we worked with at Nabu."

In Ontario, the stereotype of the lone entrepreneur is not the norm; only a quarter of the companies surveyed were founded by one entrepreneur (See Exhibit XIV.5). There is also some evidence that companies started by more than one founder have a better chance of success. Half the "struggling" companies were founded by one entrepreneur, while only three of the eighteen "growing" and "exceptional" companies had a single founder.

The majority of the founders came from other Canadian-owned companies (including those owned by the entrepreneur). Approximately one-quarter of the founders came out of the universities. Only 11 percent came from foreign-owned multinationals, and only one percent from government (See Exhibit XIV.6). These proportions are typical of start-up companies elsewhere. The best incubator of new businesses is another fully integrated company where employees are exposed to R & D or new product development, marketing, and general management. The best Ontario example of this phenomenon is Northern Telecom, which has spawned at least 50 spin-off companies. Foreign-owned branch plants in Ontario rarely claim similar achievements, often because they are not integrated businesses but simply sales offices, or they have limited manufacturing activities which are

EXHIBIT XIV.5

NUMBER OF FOUNDERS OF THE COMPANIES SURVEYED



Source: Premier's Council Survey of Ontario Start-up Companies.

reported directly back to their home country manufacturing organizations. Government, in spite of being the largest performer of R & D in Canada, was the previous employer of only one of the 184 entrepreneurs interviewed for the survey.

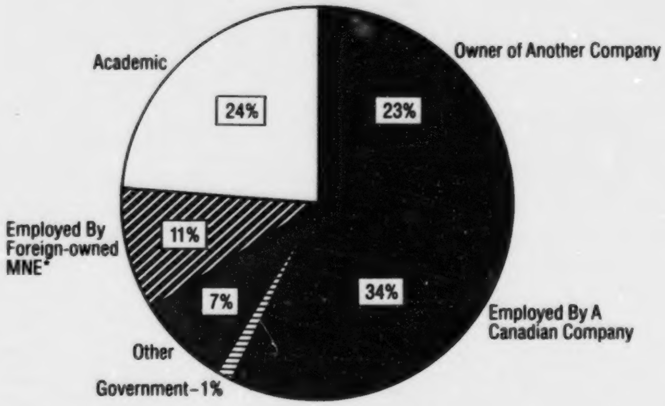
It is also noteworthy that only one percent of the original product ideas came out of government laboratories. Nearly half the entrepreneurs characterized their first product as their own idea, with no direct link to former employment. Another 30 percent of the ideas came from former employment, including university labs, and 20 percent came formally or informally from products or technology already on the market (See Exhibit XIV.7).

The Business Challenge

The interviews with company founders also sought to identify the key factors determining the success of these firms by examining areas such as marketing and distribution methods and costs, the role of key customer groups, the nature of research and prod-

EXHIBIT XIV.6

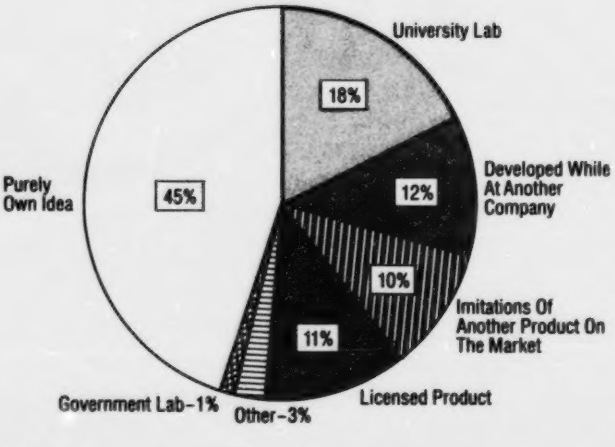
TYPE OF EMPLOYMENT OF THE FOUNDERS PRIOR TO STARTING THE COMPANY



*MNE = Multinational enterprise.
Source: Premier's Council Survey of Ontario Start-up Companies.

EXHIBIT XIV.7

ORIGIN OF THE FIRST PRODUCT OF COMPANIES SURVEYED



Source: Premier's Council Survey of Ontario Start-up Companies.

uct development activity and expenditures, and key constraints to growth.

Approximately a third of the companies got their start with a product development contract or an order from a specific customer. The majority of contracts and orders came from private sector companies, with most of the balance coming from government. Thirty-five percent of the firms began as service businesses. All but one have since become service and product businesses or have shifted entirely to selling products.

Other firms met the challenge of producing and distributing products for world markets by selling under contract to original equipment manufacturers (OEMs) who in turn sell to the end user. Twenty-two of the companies started by selling to OEMs; of these, seven continue to sell only to OEMs. Two other companies started out trying to sell to end users and have since become OEM suppliers. Companies selling only to OEMs were found only in categories 2 and 3 (growing and struggling); none of the exceptional companies began as OEM suppliers. From the interviews it appeared that companies selling directly to end users had a much better understanding of market demand, adapted products more quickly to suit customer needs, and were better able to differentiate themselves from their competitors. As a result, they were more likely to experience sustained rapid sales growth.

EXHIBIT XIV.8

CHANNELS OF DISTRIBUTION USED BY COMPANIES SURVEYED

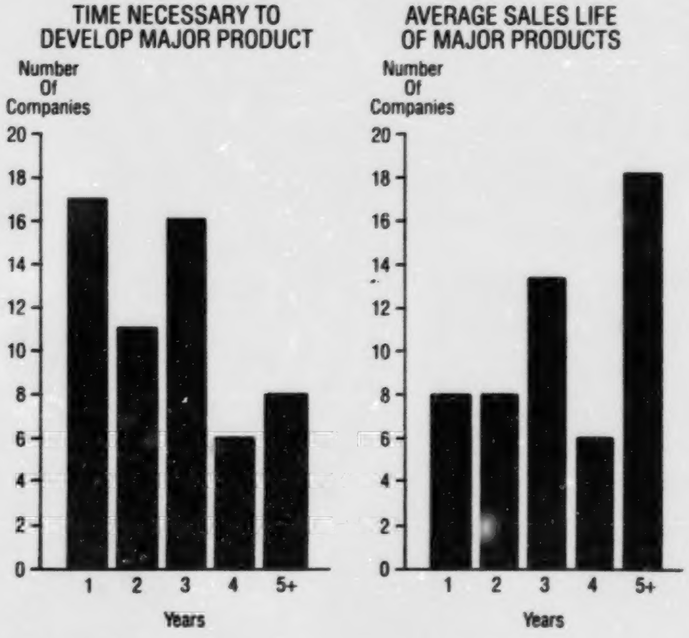
	Primary Channel	Secondary Channel
Direct sales	41	13
Distributors	16	15
Foreign sales agents	6	5
Value-added resellers	3	2
Retailers	4	1
Other	1	4
Total	71 companies	40 companies*

*40 companies indicated they had a second channel of distribution.
11 companies also indicated a third channel.
Source: Premier's Council Survey of Ontario Start-up Companies.

The primary method used by these companies to market and distribute their products is direct sales. Many firms supplement this effort with distributors in foreign countries (See Exhibit XIV.8). The survey found that marketing and distribution costs ranged widely from five percent to 60 percent of sales. Forty percent of the companies reported costs of less than ten percent of sales; others were spread between 11 and 60 percent of sales, with a larger number of companies at the higher end. This reflected the high degree of applications engineering and automation in many of the most sophisticated technological products. The struggling companies showed a lower average expenditure on marketing and distribution: only one of these firms had costs greater than 20 percent of sales. The highest average expenditures were found among growing companies, where expenditures on marketing and distribution ranged from six percent to 50 per-

EXHIBIT XIV.9

DISTRIBUTION OF PRODUCT DEVELOPMENT TIME AND SALES LIFE



Source: Premier's Council Survey of Ontario Start-up Companies.

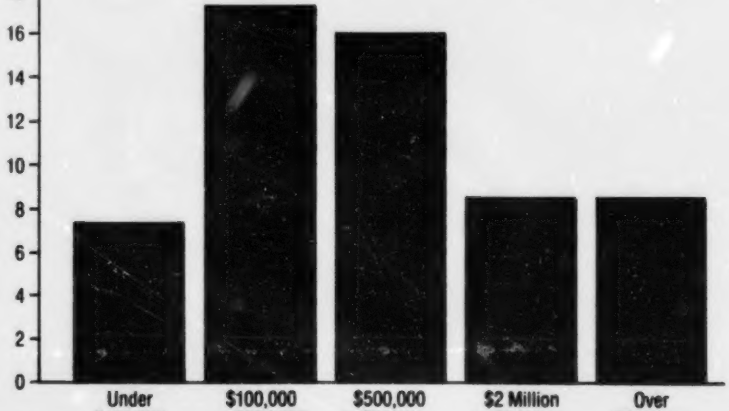
cent of sales, with companies spread fairly evenly along the range.

The high risk nature of technology-intensive firms is dramatically illustrated in their product development activity. Product development in these companies is lengthy but results in a relatively short sales life (See Exhibit XIV.9). Product development costs were at least $100,000 in most cases and often significantly more. Nine of the firms reported that the cost of developing a new product was greater than $5 million (See Exhibit XIV.10).

R & D expenditures as a percentage of sales also ranged widely among companies, from a low of less than five percent to a high of more than 50 percent (See Exhibit XIV.11). For 45 of the 71 companies, the figure was greater than ten percent of sales. As with marketing and distribution costs, the highest R & D expenditures as a percentage of sales were found among growing companies. None of the exceptional companies spent more than 15 percent of sales on R & D, while over half the growing companies spent more

EXHIBIT XIV.10

DISTRIBUTION OF PRODUCT DEVELOPMENT COST



Source: Premier's Council Survey of Ontario Start-up Companies.

EXHIBIT XIV.11

R&D EXPENDITURE AND NUMBER OF R&D EMPLOYEES IN COMPANIES SURVEYED

R&D Expenditures As A % Of Sales	Distribution Of All Companies	Number of Companies in Categories		
		1 (Exceptional)	2 (Growing)	3 (Struggling)
Less than 5%	20%	2	1	1
5–10%	16%	3	1	2
11–15%	18%	2	2	2
16–20%	11%	—	2	1
21–50%	23%	—	2	2
Over 50%	12%	—	3	1
	100%	7	11	9
R&D Employees				
1–5	31%	2	2	6
6–10	27%	2	1	1
11–15	16%	1	2	2
16–20	7%	1	1	—
More Than 20	18%	1	4	—
	100%	7	11	9

Source: Premier's Council Survey of Ontario Start-up Companies.

than 15 percent of sales on R & D, reflecting perhaps their need to continue investing in R & D at a rate sufficient to remain competitive despite their slow sales growth. The combination of long and costly product development and a rapidly changing marketplace where products can become quickly obsolete creates a volatile, high risk dynamic for these start-up companies. The rewards of success can be huge but the reality is that few will see those rewards.

Companies surveyed were asked to rate a list of potential constraints to their growth (See Exhibit XIV.12). The most serious constraint to growth identified by these firms over and over again was a lack of equity capital. Over half the firms considered this a "major constraint", and it was a "constraint" for another fifth of the firms. Other areas found to be a constraint (or major

EXHIBIT XIV.12

PERCENTAGE OF SURVEY COMPANIES INDICATING WHICH FACTORS MOST CONSTRAIN GROWTH

	Major Constraint %	Constraint %	Not A Constraint %	Total %
Lack of equity capital	54%	20%	26%	100%
Lack of debt capital at an affordable cost	29	30	41	100
Slow product development	14	38	48	100
Lack of marketing expertise	10	42	48	100
Lack of qualified personnel	10	32	58	100
Problems in penetrating foreign markets	9	28	63	100
Lack of technical or scientific expertise	3	18	79	100
Aggressive competitor response	2	31	67	100
Lack of new product ideas	2	15	83	100

Source: Premier's Council Survey of Ontario Start-up Companies

constraint) by at least half the firms were lack of debt capital at an affordable cost, slow product development, and lack of marketing expertise.

Areas not generally considered constraints to growth by at least half the firms included lack of qualified personnel, problems in penetrating foreign markets, lack of technical or scientific expertise, aggressive competitor response, and lack of new product ideas. It must be remembered that some of these were not identified as constraints for these firms because they had not yet grown sufficiently large to encounter them.

Further examination of the data on constraints to growth showed that the constraints identified by the firms reflected the

EXHIBIT XIV.13

CONSTRAINTS TO GROWTH, BY COMPANY CATEGORY

Listed in Order Of Importance

	Category 3 (Struggling)	Category 2 (Growing)	Category 1 (Exceptional)
List Of Reported Constraints To Growth	• Lack of equity capital • Slow product development • Lack of qualified personnel • Problems in penetrating foreign markets • Lack of marketing expertise	• Lack of equity capital • Lack of marketing expertise • Lack of debt capital • Problems in penetrating foreign markets • Aggressive competitor response	• Lack of equity capital • Lack of debt capital • Problems in penetrating foreign markets • Lack of marketing expertise
Major Overall Concern As Evidenced Above	Initial product development and launch	Gaining scale in marketing and distribution	Financing growth

Source: Canada Consulting and Telesis analyses.

changing concerns of evolving new businesses (See Exhibit XIV.13). Struggling firms were most concerned with initial product development and launch issues. They listed lack of equity capital, slow product development, and lack of qualified personnel as their primary constraints. For the growing companies, obstacles to gaining scale in marketing and distribution were of central concern. They listed lack of debt and equity capital and were also concerned with lack of marketing expertise and other problems in penetrating new markets. For the more established exceptional companies, financing growth was the main concern. Lack of debt and equity capital were clearly the primary constraints, followed by problems in penetrating foreign markets.

Interaction With Governments And Universities

The public and quasi-public sectors—governments, universities, hospitals, school boards, and so on—play a crucial role in the start-up phase of many firms. Public institutions are frequently investors, lenders, customers, advisors, or suppliers to start-up companies. The survey revealed many stories of contracts, loans, or other public sector assistance that became the turning point in the evolution of a new business.

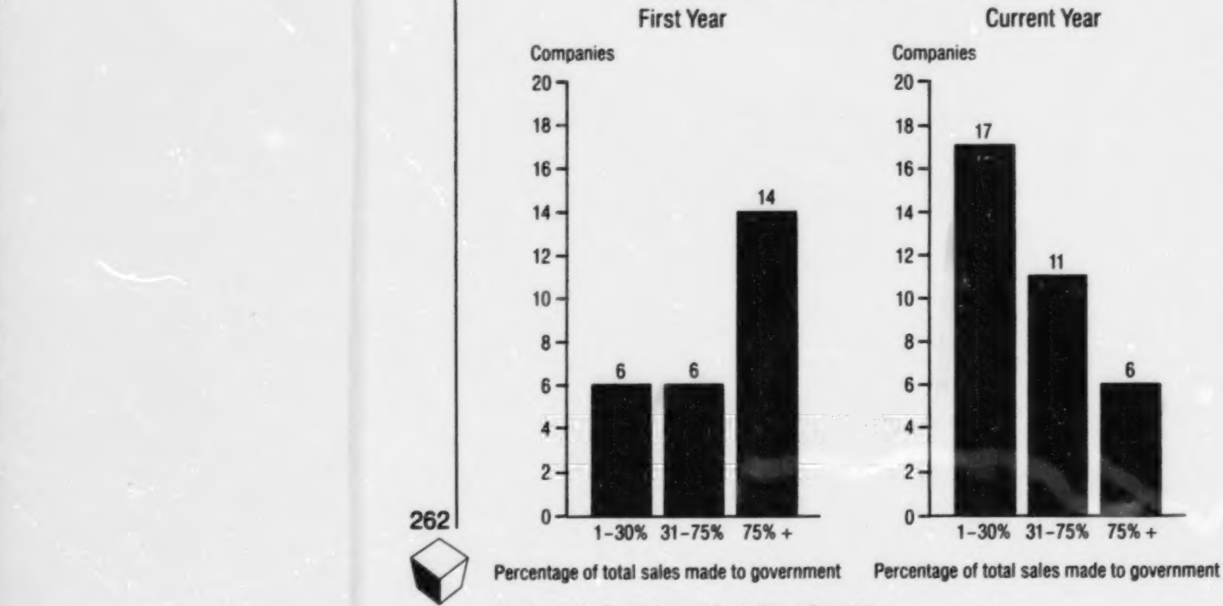
For example, 14 companies reported that government procurement accounted for 75 percent or more of their sales in the first year; an additional 12 firms also made sales (accounting for less than 75 percent of revenues) to the government in year one. After the first year, however, the proportions were reversed: more companies now made sales to the government, but for most firms this accounted for less than 30 percent of annual sales, and only six companies still relied on government for 75 percent or more of sales (See Exhibit XIV.14). The high potential of government procurement as a development tool in fostering the growth of high technology firms is evident from these figures.

Government financial assistance programs have also been important to these firms. The 71 companies interviewed had taken advantage of an average of two and a half programs each (See Exhibit XIV.15). (These figures may overstate the rate of use of government programs by all start-up companies in the economy since the list of start-up firms interviewed was drawn heavily from lists provided by government agencies.)

One of the most popular programs for these firms is IRAP—the National Research Council's Industrial Research Assistance Program. Unlike other programs, IRAP is flexible and can be tailored to the R & D needs of individual firms. Another frequently used program is PEMD—the federal Program for Export Market Development. However, many entrepreneurs reported that the funding

EXHIBIT XIV.14

SALES TO GOVERNMENT: COMPARISON OF FIRST YEAR AND CURRENT YEAR



Source: Premier's Council Survey of Ontario Start-up Companies.

available through the program is too small to make a real difference. For example, many used the program to participate in trade fairs, but after making initial contacts through a fair, companies often did not have sufficient resources to set up the infrastructure needed to make sales in the prospective new markets.

An important source of more substantial funding for these firms is the Ontario Development Corporation. Eighteen of the firms had loan or equity investments from the ODC, and several others had applied but had been turned down. Both successful and unsuccessful applicants commented on the substantial amount of time involved in applying for the loans.

Overall, assistance programs were considered valuable, but companies often found that the pursuit of government funding could be time-consuming and unrewarding. Several entrepreneurs reported that they had spent so much time chasing assistance programs that they had neglected their customers and lost sales. In a small firm, where the founder is frequently both head scien-

EXHIBIT XIV.15

DISTRIBUTION OF COMPANIES USING VARIOUS GOVERNMENT ASSISTANCE PROGRAMS

	Number of Companies	
Type of Assistance Program	Using Federal Programs	Using Provincial Programs
R&D - IRAP (Federal program)	31	N/A
- Other	16	4
Marketing, export assistance	34	13
Employment (summer students, etc.)	17	21
Ontario Development Corporation	N/A	18
Federal Business Development Bank	4	N/A
Other loans	1	3
Equity investment from government	2	14
Total responses: 178	105	73

Source: Premier's Council Survey of Ontario Start-up Companies.

tist for product development and the key marketing representative, time away from these functions to obtain supplementary funding can be very costly indeed. Software writers who stop developing programs to spend weeks looking for government assistance can never recapture that time, even with additional financial help. Without exception, every company interviewed commented that simpler, more effective access to funding should be developed. As one entrepreneur put it, "One branch of the government spends hours with me to approve an R & D grant, while another branch, the Department of Supply and Services, won't even consider buying my products whose development the government has funded."

Another common observation by the firms was that it is much easier to find R & D money than to find assistance for commercializing a newly developed product. One entrepreneur reported that his product launch costs had been five times the cost of R & D. Unfortunately, the level of funding available through assistance programs is reversed: hundreds of thousands of dollars are available for qualifying R & D, but only a few thousand for marketing and product launches. It is not unusual to find many Ontario products developed through the R & D stage but failing to reach full commercialization because of a lack of funding.

In spite of these concerns, the survey showed that use of government programs probably does contribute to success. Growing companies used twice as many assistance programs as the struggling companies had. The exceptional category fell about halfway between (See Exhibit XIV.16). It may also be true that more successful entrepreneurs are more adept at locating and using relevant assistance programs.

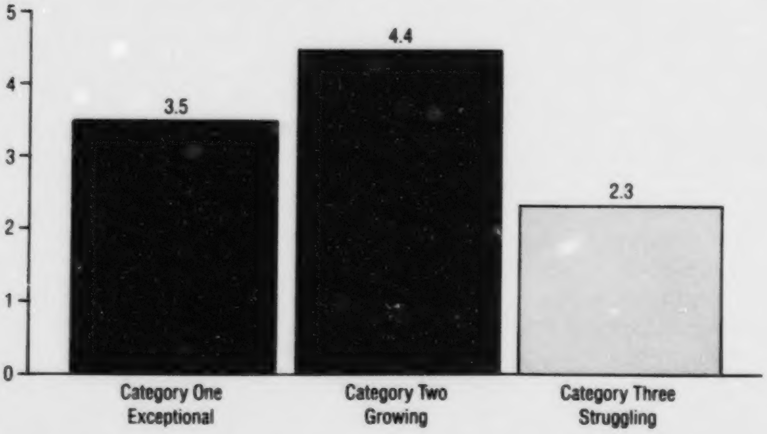
More than 80 percent of the firms selected for the Premier's Council survey had some interaction with universities. In most cases, it was an informal relationship, such as exchanging ideas and information with former colleagues or associates. Approximately a third of the firms had an R & D or other consulting contract with a university. Many found, however, that the long time frames of university research did not suit their fast-paced environment, where technology and opportunities can shift from one day to the next.

A CASE STUDY OF BNR SPIN-OFF COMPANIES

Northern Telecom (and its affiliate, Bell Northern Research)

EXHIBIT XIV.16

AVERAGE NUMBER OF GOVERNMENT ASSISTANCE PROGRAMS USED, BY COMPANY CATEGORY



Source: Premier's Council Survey of Ontario Start-Up Companies.

have played a unique role in the formation of Ontario's community of high-technology entrepreneurs. More than 50 companies have been formed by former NT or BNR employees (See Exhibit XIV.17). A special study of these firms was undertaken to understand the role of the "incubator" company before and after a new spin-off company forms.

The majority of the spin-off company founders surveyed viewed Northern Telecom as a source of technology and training, but not as an active player in the formation and success of their business. There are a few important exceptions, however. For example, Orcatech was formed when Bell Northern Research decided not to continue developing its own microcomputer work station. The internal design group at BNR wanted to go ahead with the project and to produce and sell the machine they had developed. BNR licensed the technology to the designers in return for equity in their new company, Orcatech.

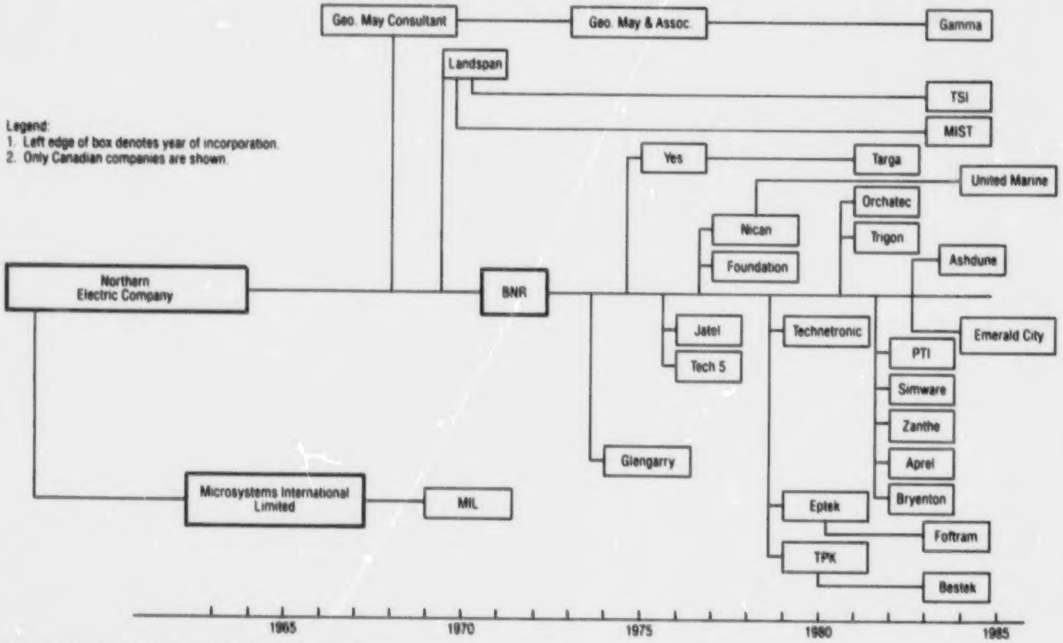
In most cases, though, there was no formal transfer of technology. Entrepreneurs took with them concepts and a management "culture" rather than a specific product technology. All of those interviewed felt that Northern Telecom's most important contribution to them was in their on-the-job management training. Most of the entrepreneurs had the opportunity to be involved in a variety of general management activities, as well as leading-edge research at Northern. This was in marked contrast to most Canadian managers in foreign multinationals, who were rarely exposed to all aspects of a multinational technology business.

Although many of the company founders continue to associate with former BNR or Northern Telecom colleagues, there was very little evidence of continuing business (customer or supplier) relationships between them. Fewer than half the companies interviewed indicated that BNR or Northern Telecom was a customer, and in all cases sales to those two firms accounted for less than 25 percent of total sales.

These spin-off companies face financing problems similar to those of other start-up companies surveyed. Analysis of the sales growth of 12 of the BNR and Northern spin-offs found a correlation between the entrepreneur's willingness to give up ownership to obtain outside equity financing and the rate of sales growth of the firm. Companies with annual sales of less than $1 million all reported founders retaining 100 percent ownership of the firm. In contrast, the founders of all but two companies with sales greater than $1 million had given up substantial ownership. In fact, the two largest companies began with 100 percent financing from outside investors.

EXHIBIT XIV.17

ORIGINS OF BNR SPIN-OFF COMPANIES



Legend:
1. Left edge of box denotes year of incorporation.
2. Only Canadian companies are shown.

Note: This chart does not include Northern Telecom, MIL or Mitel spin-off companies.
Source: Bell Northern Research.

THE CRITICAL ROLE OF VENTURE CAPITAL

The problems encountered by Ontario entrepreneurs in raising equity led to another study of the venture capital industry. Venture capital plays a critical role in the creation and success of start-up companies in many parts of the world. New businesses generally lack the assets and track record necessary to obtain bank financing; instead they must look for individuals or companies willing to invest in their prospects for future success. For many companies, the first investor is the entrepreneur, followed by family, colleagues, and friends.

But the high capital costs and long development cycles of many new products soon exhaust these initial investments. At this point, many entrepreneurs seek arm's-length equity financing, and the Premier's Council survey found that in Ontario, obtaining outside equity can be a difficult and frustrating process.

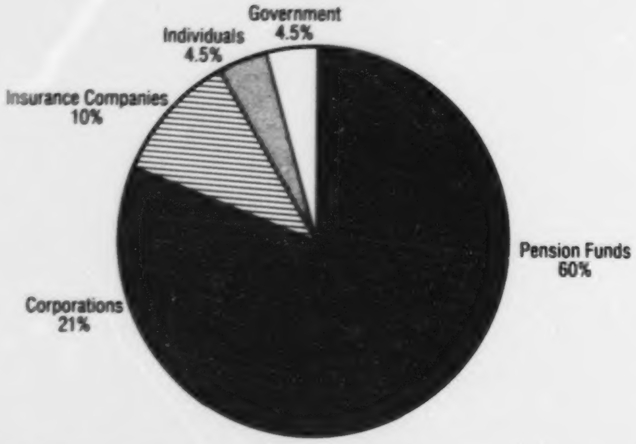
The Canadian venture capital community is relatively small, with a total investment in 1986 of less than $250 million. Approximately one-quarter of these funds goes into early-stage financing

EXHIBIT XIV.18

SOURCES OF VENTURE CAPITAL FUNDS IN CANADA

Average Annual Funds Raised, 1985-1986

$107.0 Million*



*Funds raised in a given year will be disbursed over several years; venture capital disbursements may exceed funds raised in any given year.

Source: Venture Economics Canada.

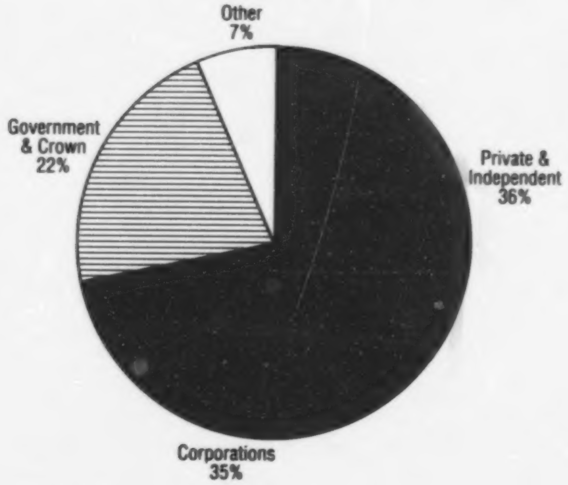
of new businesses, making the total pool available to all Canadian entrepreneurs starting at less than $60 million. Most Canadian venture capital comes from pension funds; the balance is from insurance and other corporations, government, and individuals (See Exhibit XIV.18). These funds are disbursed through corporate venture capital departments, independent venture firms, and government and Crown corporations (See Exhibit XIV.19).

Although still small, Canadian venture capital investment has increased substantially in the last few years, from $124 million in 1984 to $206 million in 1986 (See Exhibit XIV.20). However, the proportion of funds directed to early-stage financing (i.e. seed, start-up, and development funding) is dropping off dramatically, and the absolute amount is actually declining (See Exhibit XIV.21). (See Chapter VII of Volume 1 of the Premier's Council Report for a description of the stages of start-up company development and financing). Small business (fewer than 50 employees) still accounts for close to half of all investments, but that figure has also declined considerably (See Exhibit XIV.22).

EXHIBIT XIV.19

CANADIAN VENTURE CAPITAL DISBURSEMENTS BY TYPE OF VENTURE CAPITAL FIRM

1985-86 Annual Average
$227.0 Million

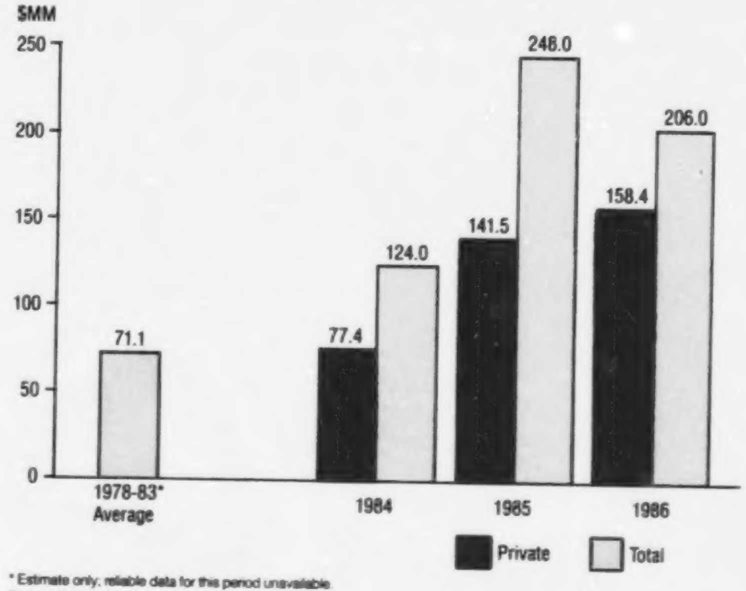


Source: Venture Economics Canada.

EXHIBIT XIV.20

GROWTH OF VENTURE CAPITAL DISBURSEMENTS IN CANADA

Private Sector and Total
1978-86



* Estimate only; reliable data for this period unavailable.
Source: Venture Economics Canada

Just over half of all venture capital investment in Canada is made in technology-based firms (See Exhibit XIV.23). Computer and telecommunications-related companies receive the majority of these investments. The high growth of technology-driven industries make them particularly attractive to venture capitalists.

Historically, Canadian venture capitalists have invested heavily outside Canada. As recently as 1984, up to 40 percent of all Canadian venture capital funds were invested in foreign countries. However, this proportion has declined dramatically in recent years and by 1986 was less than 15 percent. Just over a third of the Canadian investments are made in Ontario. Alberta and Quebec are also major locations for venture capital investment. All other provinces make up less than 15 percent, and that proportion appears to be declining.

EXHIBIT XIV.21

PRIVATE SECTOR VENTURE CAPITAL INVESTMENT:
Amount and % at Various Stages in the Investment Cycle

Stage in Investment Cycle	Average 1979-84		1985		1986	
	$MM	%	$MM	%	$MM	%
Early Stages						
Start-up, seed	$20.2	25%	$24.8	18%	$28.8	18%
Development	17.8	22	5.2	4	7.6	5
Expansion	22.9	28	50.3	36	59.0	37
Leveraged Buyouts	11.9	15	13.3	9	32.1	20
Other (including turnarounds)	6.6	8	47.9	33	28.2	18
Unstated	2.3	2	—	—	2.7	2
Total	$81.7	100%	$141.5	100%	$158.4	100%

Source: Venture Economics Canada.

EXHIBIT XIV.22

TOTAL VENTURE CAPITAL INVESTMENT BY FIRM SIZE

Percentage Distribution of Number of Investments by Number of Employees

Number of Employees	Average 1981-84	1985	1986
0-49	68%	58%	47%
50-99	12	16	13
100-199	7	12	14
200-499	9	10	11
500 +	4	4	15
Total	100%	100%	100%

Source: Venture Economics Canada

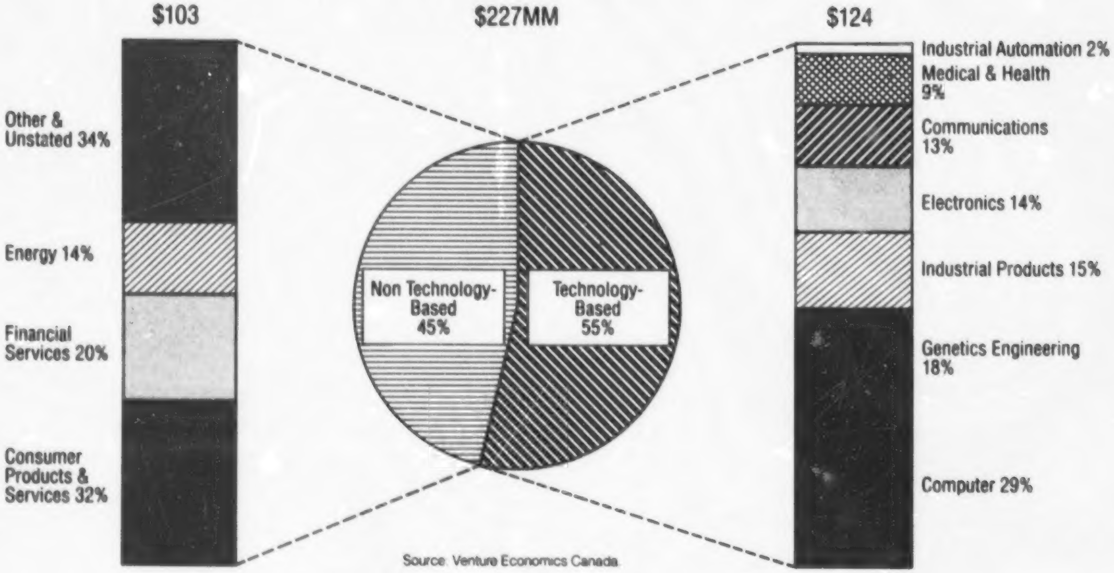
From a global perspective, Canada's venture capital community is as developed as that of most countries, although it lags behind the more highly developed U.S. and U.K. markets. Canada's $248 million investment in 1985 made it the third largest in the world (See Exhibit XIV.24). The United States is by far the largest player, with a 1985 investment of $3.5 billion, followed by the United Kingdom at $575 million. The importance of venture capital financing in a country can be measured by calculating the investment level as a percentage of Gross Domestic Product (GDP). On this basis, Canada is an average player, with venture capital investment at .05 percent of GDP.

Despite its much larger size, the U.S. venture capital community also shows a decline in the amount and proportion of funds directed to early-stage investments. Although investment by the industry as a whole jumped 33 percent in 1986, seed and start-up stage investing fell by three percent. The proportion of total funds devoted to these early-stage investments in 1986 was 14 percent, down from 19 percent in 1985.

A significant difference between the U.S. and Canadian venture capital industries is the share of funds invested by independent sources. Seventy-five percent of venture capital funds in the United States are invested by independent private firms, compared to only 40 percent in Canada (See Exhibit XIV.25). In

EXHIBIT XIV.23

TOTAL VENTURE CAPITAL INVESTMENTS
BY SECTOR
Technology Versus Non-Technology-Based
1985-86 Annual Average



Source: Venture Economics Canada

EXHIBIT XIV.24

TOTAL VENTURE CAPITAL INVESTMENT
Canada and Selected Countries

Country	Total Investments 1985 $MM	Percentage of GDP	Rank in GDP
United States	$3,536	.07%	1
United Kingdom	575	.09	3
Canada	**248**	**.05**	**5**
Netherlands	204	.12	7
West Germany	155	.02	2
France	147	.02	4
Belgium	126	.11	6
Ireland	48	.19	9
Denmark	23	.06	8
Israel	12	.04	10

Source: Telesis analysis based on Venture Economics Canada/European Venture Capital Association/Venture Capital Journal and industry interviews.

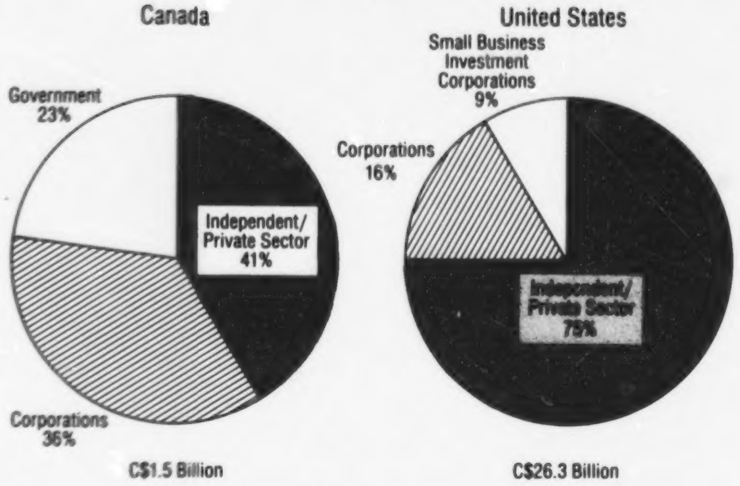
Canada, the role of government venture capital funds is much more important, with 23 percent of total investments coming from such funds. Sources of funds for venture capital also differ: in the United States pension funds make up only 40 percent of capital available, and individuals and foreign firms play a much larger role in funding. In Canada, most funds come from pension funds.

POLICY IMPLICATIONS

Research for the Premier's Council in Ontario and abroad has found that a combination of factors is necessary to create a climate that fosters technically innovative new businesses in traded

EXHIBIT XIV.25

TOTAL VENTURE CAPITAL FUNDS COMMITTED
Canada and the United States
1986



Source: Venture Economics Canada.

sectors. Some of these can be created, or at least encouraged, by carefully targeted public policies. These factors include:

- **The presence of other entrepreneurs**

Incubator companies, often new businesses themselves, in turn spawn other companies. Existing entrepreneurs also serve as role models, introducing to would-be entrepreneurs the possibility of starting a business, and reducing the perceived risk of launching a new business.

- **Volatility in technology and in society**

Technological volatility opens new product and market opportunities. Social volatility, through immigration and industrial change, creates the need for new employment opportunities, often outside the mainstream of large corporations.

- **Access to capital**

Venture capital, especially where the investor becomes actively involved, has been shown to improve an entrepreneur's chances of success. The personal resources of the entrepreneur, family, and friends can also contribute to success, as can other sources of financing, such as seed capital from incubator companies, government loan guarantees, etc.

- **Tax incentives**

Tax advantages, such as reduced capital gains tax, can play a role in encouraging both entrepreneurs and their investors.

- **Science and technology infrastructure**

The presence of research universities and public institutions does not in itself create start-up companies, but they play an important role, first in education and later in networking for entrepreneurs.

- **Political and cultural climate**

A substantial number of new businesses are started on the basis of government procurement contracts. This is especially true in countries whose policies favour the development of indigenous firms. It is also worth noting that many entrepreneurs have become folk heroes in North American culture, while in Japan, for example, loyalty to one's employer is valued far more highly.

POLICIES TO FOSTER START-UP COMPANIES

Government policy and programs can play a role in fostering an entrepreneurial culture by increasing the number of start-up companies and improving the success rate of those that do form.

Increasing the number of start-up companies can begin by simply increasing public awareness of the idea of starting a company and giving public recognition to successful entrepreneurs. Initiatives to include entrepreneurship in education and training courses, such as the Centres of Entrepreneurship created by the Premier's Council, help achieve this goal. Minimizing the paperwork and cost involved in establishing a business is another important public sector signal to would-be entrepreneurs. A more subtle challenge is to find ways to reduce the risk and costs of failure for both entrepreneurs and their investors. These issues are addressed in the Council's proposals for an Initial Public Offering Incentive and licensed venture capital funds described in Volume I.

These programs would also address the need to improve the success rate of start-up companies. Access to capital was found overwhelmingly to be the most critical issue for Ontario start-up companies; this was accounted for to some extent by Ontario's underdeveloped venture capital industry and public markets for initial public offerings. Other fundamental points of leverage to increase the success of start-up companies are tax credits and procurement policies. Policies to address these issues were described in the chapter on high growth and emerging industries in Volume I.

LESSONS FOR ONTARIO

The findings of the survey of Ontario's entrepreneurial sector have specific implications for policy development. Any new initiatives aimed at increasing the number and improving the success rate of start-up companies must:

- **Create a climate that tolerates failure**. Many entrepreneurs start several companies, often succeeding only the second or third time around. Government policies and programs should not automatically discriminate against entrepreneurs on the basis of previous failures in funding new ventures.
- **Support the success of growing Canadian firms**. These are the most likely incubators of new companies. The high level of foreign ownership in Canada tends to reduce the overall rate of new business start-ups because entrepreneurs seldom come out of multinational branch plants. Policies which support the growth of Ontario threshold companies into indigenous worldwide multinationals will also pay substantial benefits in the creation of new spin-off businesses in traded industries.
- **Encourage new business to sell to end users as much as is competitively feasible**. Sales success in selling to original equipment manufacturers can be short-term and often does not build a sound foundation for sustained growth because it isolates entrepreneurs from end-users. Canadian companies should be encouraged to scale up or, if necessary, to merge to create the scale required to fill large procurement contracts. They should generally not be encouraged to participate in a secondary role through OEM contracts with large foreign suppliers except as a last resort. Current federal procurement policy is wrong-headed in this regard because it promotes OEM supply as the preferred alternative for Canadian high tech firms.
- **Foster a more participative venture capital industry**. Fund managers should be encouraged to take an active role in advising and sustaining the firms they fund. Many successful Silicon Valley and Boston entrepreneurs—as well as Ontario entrepreneurs backed by our participative venture capital firms—attribute their success in part to the skills and contacts of their investors.

These and other conclusions from the Council research, including specific recommendations, were elaborated upon in Volume I of the Premier's Council Report.

CHAPTER XV
ONTARIO HYDRO'S ROLE IN PROVINCIAL DEVELOPMENT

Ontario Hydro is one of the most important potential tools of economic development available to the provincial government. In terms of revenue, Hydro is among the ten largest electrical utilities in North America, with sales of about $5 billion in 1986 (See Exhibit XV.1). But sales figures understate Hydro's relative scale somewhat because Hydro does not serve a significant retail market, leaving most of that to local distribution utilities. In terms of physical assets and number of employees, Ontario Hydro is probably the largest single electrical utility in North America. It is also Canada's largest corporation in terms of physical assets and unique among North American utilities in its well diversified participation in all three major electricity generation activities: hydro (25 percent), coal (25 percent), and nuclear (50 percent).

In support of its electrical generation and transmission activities, Ontario Hydro operates the largest research and development program of any electrical utility in North America. Hydro spends about $100 million each year on R & D, making it the fifth largest R & D spender among Canadian corporations (See Exhibit XV.2). (This includes some research done on behalf of other utilities at Ontario Hydro's facilities.)

Hydro is one of the largest buyers of materials, equipment, and services in Ontario. Its annual purchases, excluding fuel, will be in the range of $700 million to $800 million through 1992 (See Exhibit XV.3). Its purchases range from nuclear generating equipment to construction materials, computers, and transmission towers. They include many items of high technology as well as traditional products with very little technology content.

HYDRO'S POINTS OF ECONOMIC LEVERAGE

Ontario Hydro's primary goal is to provide safe, reliable, and economical electric power to the province. It must never lose sight of this central mandate, and it will be by achieving this mandate that Hydro can make its most substantial contribution to provincial economic development. However, because of its size and scope, Hydro also offers unique possibilities to assist the province in achieving economic goals beyond its central mandate. This potential has long been acknowledged, perhaps most importantly

EXHIBIT XV.1

TOP TEN NORTH AMERICAN ELECTRICAL UTILITIES BY 1986 ELECTRICITY SALES
(Cdn. $)

Company Name	Head Office Location	Electricity Revenue[1] (Cdn. $)
1. The Southern Company	Atlanta, GA.	8,500
2. Pacific Gas & Electric	San Francisco, CA.	7,000
3. Commonwealth Edison	Chicago, IL.	6,900
4. Southern California Edison	Los Angeles, CA.	6,600
5. American Electric Power Co.	Columbus, OH.	5,900
6. Consolidated Edison	New York, N.Y.	5,300
7. FPL Group	Miami, FL.	5,100
8. Texas Utilities	Dallas, Texas	4,900
9. Ontario Hydro	Toronto, Ontario	4,900
10. Quebec Hydro	Montreal, P.Q.	4,700

[1] Includes only electricity revenue, not other businesses. Exchange rate used is $1 U.S. = $1.25 Canadian.

Source: Electric Light and Power Magazine, June 1987; Ontario Hydro.

EXHIBIT XV.2

THE TEN LARGEST R & D SPENDERS IN CANADA[1]

	Projected 1987 R&D ($ Millions)
Bell Canada Enterprises (includes Northern Telecom)	$687
Atomic Energy of Canada	172
Pratt & Whitney	149
IBM Canada	138
Ontario Hydro	**99**
Alcan Aluminum	61
Imperial Oil	60
Hydro Quebec	60
Mitel	56[2]
CAE Industries	50

[1] Includes self-reported R&D funded and perfomed by the companies themselves

[2] 1986 figure. 1987 projection not available

Source: Financial Post Annual R&D Survey

in the critical role Hydro played as a customer and thus a prime developer of Canada's nuclear power industry.

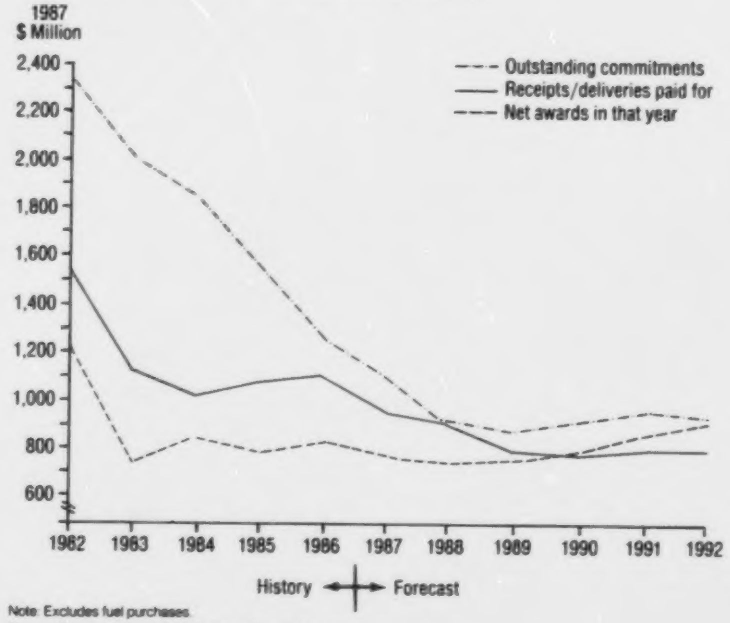
Ontario Hydro can assist provincial economic development beyond its central mandate by four principal means:

- Procurement of Ontario goods and services
- Spin-off businesses from its core activities
  - material by-products from electricity generation
  - expertise related to the utility business
- Creation of new technologies and products through its research and development
- Electricity rate reductions for targetted industries or regions.

Each of these means represents a potentially significant lever that Hydro can employ to serve provincial economic goals. At present Hydro is using all four levers with varying degrees of success; it is fair to say that at present each in its own way is probably underutilized relative to what could be achieved.

EXHIBIT XV.3

ONTARIO HYDRO SUPPLY DIVISION PROCUREMENT HISTORY AND FORECASTS



Note: Excludes fuel purchases.

Source: Ontario Hydro Division Business Plan, Table 1.

Procurement represents the most powerful development tool at Hydro's disposal. Traditionally, Hydro has not viewed procurement in strategic terms, although a preference for Canadian goods and services was always exercised when possible. In recent years, Hydro's procurement staff have become much more involved in targeting key areas where opportunities for Ontario manufacturing can be encouraged through procurement decisions.

With regard to developing spin-off businesses from Hydro's expertise and material by-products, Hydro has made vigorous efforts in the past few years. Since 1984, these activities have been centralized in a New Business Ventures Division (NBV), which sells various spin-off products and services. Since its establishment, this group has quadrupled its sales, from $12 million in 1984 to about $48 million in 1987. Despite the Division's success to date, many opportunities have not been fully tapped, and structural changes to allow NBV wider development latitude (such as the ability to hold equity in other corporations) are probably needed to take full advantage of Hydro's potential.

In research and development, there have been some important successes in products developed for Hydro that have gone on to be marketed elsewhere. Given the size and scope of Hydro's research, there may be more spin-off opportunities in existing research efforts. Certainly, there are significant opportunities to use future-oriented research more effectively as an enabling tool, helping Canadian companies to develop the ability to supply high technology products to Hydro and to export markets.

The final development lever, electricity rate reductions, is now being used by Hydro on a marginal cost basis for Northern Ontario industry. The benefits of such reductions should come in increased investment by energy-intensive businesses in the North—particularly pulp and paper, although there is a distinct possibility that such reductions may be severely curtailed or eliminated under the proposed Canada-U.S. Free Trade Agreement. Because of their regional focus and recent introduction, the effectiveness of rate reductions as an economic development tool are not discussed in this chapter, which focusses instead on analyzing the potential of the first three economic levers: procurement, related business spin-offs, and R & D.

SUPPORTING THE PROVINCE'S OBJECTIVES

Any Ontario Hydro strategy for promoting economic development should be linked to and follow the thrust of overall provincial objectives. In Volume I of its report, the Premier's Council articulated a set of development principles to guide provincial economic development efforts. Three of those principles are of special importance to Ontario Hydro:

- Focus development efforts on internationally traded goods and services
- Assist businesses to achieve sustainable competitive advantages in international markets
- Encourage development of activities and products with higher value-added per employee.

Foremost among these principles is the need to focus development efforts on internationally traded goods and services. These include most manufactured products, but very few services are traded internationally. Hydro will inevitably play a role as a major buyer of non-traded services such as construction and real estate, as well as materials like gravel. From its ordinary activities Hydro may also create spin-off businesses that are only domestic in nature. However, these non-traded products or businesses should not be of central development concern. Instead, in product areas where Hydro is procuring or could spin off products that can be exported or imported, like electrical generators or consulting engineering services, Hydro must have clear and effective development policies.

In applying the second development principle Hydro would have to emphasize procurement, spin-off, or research and development policies that can assist Ontario firms gain the international competitive advantages which eventually produce sales outside the province. Offset projects that capture local content for Ontario but do not yield international competitiveness are not effective industrial policies for the long term.

The importance of the third development principle for Hydro is that development policies should be directed at raising the value-added per employee in current industrial activities and encouraging a shift to new activities with higher value-added per employee. All other things being equal, higher value-added businesses can create more wealth for the province and pay higher wages than jobs where value-added per employee is lower. For Hydro this could mean looking for opportunities to move beyond commodity spin-offs from nuclear operations, such as radioactive isotope production, to opportunities that create higher value-added jobs in applications engineering, research and development, and marketing of knowledge-intensive products based on the low-cost isotope capability at Hydro. These businesses and jobs could be inside or outside Hydro, as appropriate.

Beyond its central mandate to provide low-cost power, Ontario Hydro's industrial development efforts should be measured against these three principles. In the rest of this chapter we discuss Hydro's current use of procurement, spin-offs, and R & D and assess Hydro's relative success in achieving the policy objectives articulated by the Premier's Council.

THE ROLE OF PROCUREMENT

Ontario Hydro is one of the province's largest single buyers. Hydro's net new procurement awards in 1986 (not including fuels) totalled $765 million and are expected to average $700 million to $800 million a year until 1992 (See Exhibit XV.3). Of Hydro's purchases, not including construction materials, 65 percent were made in Ontario and 23 percent abroad (See Exhibit XV.4). Hydro's procurement level has dropped significantly since 1982, when new orders worth over $1.2 billion were placed. Outstanding procurement commitments at that time were nearly $2.4

EXHIBIT XV.4

PURCHASE VALUE BY POINT OF MANUFACTURE OF HYDRO SUPPLIES

(Excluding Fuels and Construction Materials)
1986

Jurisdiction	$ (Millions)	%
Ontario	410	65
Quebec	47	7
Other Provinces	26	4
United States	115	18
Other Countries	33	5
Total	$631	100%

Source: Supply Division Annual Report Of Procurement Activity, 1986 and estimates by Ontario Hydro.

billion, mostly because of major nuclear construction programs at Bruce and Darlington. Nuclear construction expenditures will decline dramatically between now and 1992 as those projects are completed.

However, new capital expenditures in several other areas will keep Hydro purchases at a significant level throughout the 1990s. These include major new construction and rehabilitation programs in hydro and fossil generation and greatly increased building of transmission lines (See Exhibit XV.5).

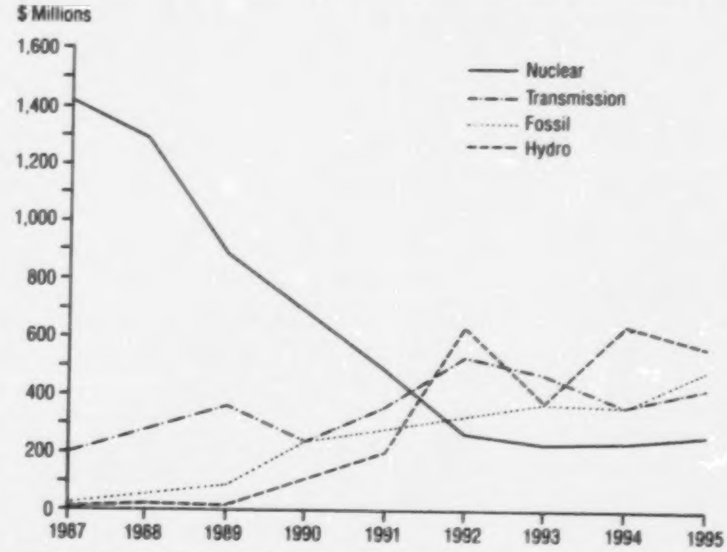
Overall capital spending on projects of the Design and Construction Branch will rise from $1.745 billion in 1987 to $2.089 billion in 1995. In addition to these expenditures, Hydro will spend millions of dollars annually on capital projects and operating supplies in other parts of its businesses.

The opportunity for Hydro to use procurement to help Ontario firms develop international competitive advantages depends very much on what is being procured. Construction costs account for a high proportion of the cost of many Hydro capital projects; however, construction services are of necessity site-specific and thus are not traded. Engineering services on the other hand can be traded. Engineering costs can range from ten percent in transmission line projects to about 25 percent of total costs (net of interest) in a nuclear plant, a fossil fuel plant rebuild, or a flue gas desulphurization project (See Exhibit XV.6). The province of Que-

EXHIBIT XV.5

ONTARIO HYDRO CAPITAL PROGRAM DESIGN AND CONSTRUCTION

Hydro, Fossil, Transmission, and Nuclear Projects, 1987–1995*



* Design and Construction Branch projects: does not include transformation, telecommunication, and other capital expenditures.

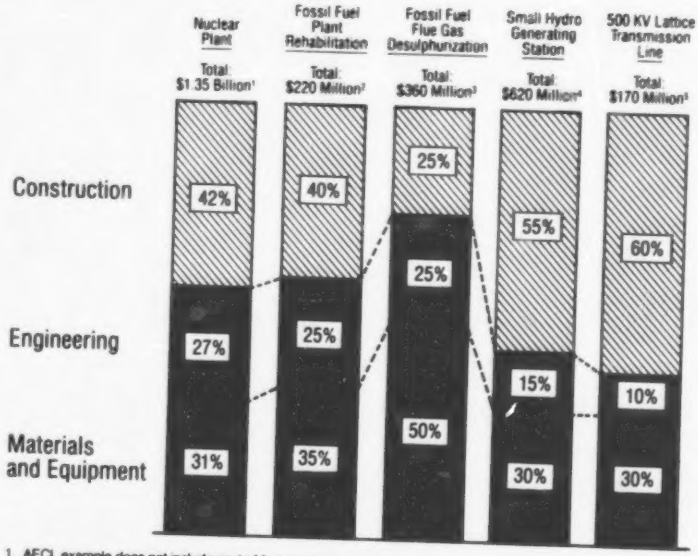
Source: Ontario Hydro Business Plan, Appendix 2, May 1987.

bec, taking advantage of the fact that engineering services can be traded, has used the procurement of engineering services in hydro projects with considerable success in assisting the development of the Quebec engineering industry.

Purchased materials and equipment make up the remainder of most Hydro capital project costs. These can vary from commodity items like structural steel, concrete, pipe, and wire to more specialized instrumentation and control devices, turbines, generators and computers (See Exhibit XV.7). The commodity purchases constitute the largest dollar volume. For example, Hydro's purchases of steel products for its flue gas desulphurization, small hydro station, and transmission line projects over the period 1987-1997 are estimated at $750 million to $850 million. By contrast, Hydro expects to purchase a total of $254 million worth of control and instrumentation devices for flue gas desulphurization, fossil fuel rehabilitation, and transmission projects over the same period

EXHIBIT XV.6

TYPICAL HYDRO CAPITAL PROJECT COST BREAKDOWNS



1. AECL example does not include cost of fuel and heavy water.
2. Estimated cost of Lakeview rehabilitation net of interest during construction.
3. Estimated cost of first two units at Lambton net of interest during construction.
4. Estimated cost of Little Jackfish Hydro project net of interest during construction.
5. Estimated cost of one Nanticoke to London area 500 KV line net of interest during construction.

Source: Telesis and Canada Consulting estimates based on interviews at Ontario Hydro and AECL, and the OH Design and Construction Branch 1987 Business Plan.

(See Exhibit XV.8). However, it is in the area of control and instrumentation devices that Hydro may be best able to play an important role in fostering internationally-oriented Ontario competitors. Hydro's steel consumption, while significant, still represents a very small part of Canadian steel output; as a result, its purchases are not likely to have great effects on the costs or competitiveness of Canadian steel producers.

Hydro's Local Content Procurement Policy

In general, Ontario Hydro has used the economic development power of procurement only in its simplest form—that of discriminating in favour of Canadian-made products over those from outside Canada. Like all other electrical utilities in Canada, Ontario Hydro offers a generalized price preference to domestic manufacturers. Unlike most other Canadian utilities, Ontario Hydro construes "domestic manufacturers" to be Canadian ones. Hydro

EXHIBIT XV.7

MATERIALS AND EQUIPMENT COSTS FOR VARIOUS HYDRO CAPITAL PROJECTS

Fossil Fuel Plant Rehabilitation	Fossil Fuel Flue Gas Desulphurization	Small Hydro Generating Station	500 KV Lattice Transmission Line
50% Turbine Generator components and parts for heat exchangers, pumps, valves 20% Instrumentation and control, including computers, cable 20% Pipe 10% Other, including structural steel, plate, etc.	30% Structural steel & plate 20% Pumps, valves, fans, tanks, etc. 20% Pipe 20% Instrumentation & controls, cable 10% Other, including concrete, re-bar, building materials	50% Turbine, generator, control gates, cranes, etc. 50% Other, including steel, cement, pipe, cable, etc.	48% Steel 21% Hardware and ground cables 15% Conductors 10% Insulators 4% Concrete 2% Re-bar
100%	100%	100%	100%

Source: Telesis and Canada Consulting estimates based on interviews at Ontario Hydro

EXHIBIT XV.8

ESTIMATE OF HYDRO'S NEEDS FOR CONTROL AND INSTRUMENTATION DEVICES

1987–1997

($ Millions)

Branch	Program/Project	Amount	Product
Design & Construction	Fossil—Rehabilitation Project	$ 46	Instrumentation & control, including computers
Design & Construction	Fossil—Flue Gas Desulphurization	139	Instrumentation & control including cable
Design & Construction	New— 500, 230, and 115 KV stations	69	Control, meter, and relay
	Subtotal	$ 254	

Source: Telesis and Canada Consulting estimates based on interviews at Ontario Hydro

Quebec and other utilities give preference to companies in their provinces over those in other parts of Canada. In Ontario Hydro's case the domestic price preference is ten percent—that is, non-Canadian suppliers have a ten percent penalty added to their bids.

Ontario Hydro (like most other utilities) exercises an even more powerful preference in its process for qualifying bidders. If Ontario Hydro can find two or more capable and fully competitive Canadian suppliers willing to bid on a contract, it does not open the bidding to foreign firms. Again, in Quebec the qualification to bid process is used to favour Quebec-based companies, not Canadian firms in general.

These domestic preferences in bidder qualification and pricing are based on the assumption that Ontario Hydro should, as far as possible, encourage domestic economic activity without placing an undue burden on the electricity consumer. Having at least two domestic bidders is expected to offer enough competition to ensure a fair price to Hydro.

Hydro's current approach to procurement might be termed a 'local content' approach. Local content is favoured whenever it can be obtained without too much extra cost to the consumer. Most government-owned utilities around the world practise such local content purchasing. Even many U.S. utilities that are not government-owned have local content policies in the form of "Buy America" provisions (See Exhibit XV.9).

Simple local content purchasing has one major drawback from the perspective of economic development. It usually extracts only the present economic value of a government purchase and does little to create future economic activity after the procurement contract has been fulfilled. The success of a local content procurement policy is measured only by whether a product was procured locally rather than from abroad.

Local Content Versus Strategic Procurement

An alternative approach to procurement can net more long-lasting gains to the economy: we refer to it as 'strategic procurement'. In strategic procurement the goal is to assist local suppliers, through procurement, to develop and test new products, broaden or deepen their experience, reduce their costs, and generally become more competitive in world markets.

Strategic procurement requires an understanding of the international competitive environment facing domestic suppliers so as to be able to identify the most critical leverage points for gaining a competitive advantage in each business. In some businesses, new product development is a critical competitive tool. Strategic

EXHIBIT XV.9

EXAMPLES OF PROCUREMENT POLICIES AT MAJOR NORTH AMERICAN PUBLIC UTILITIES

Name	Preferential Procurement Policy
Detroit Edison	• No location-specific price premiums added, except to offshore suppliers, and then done for inconvenience • Allow any and all bidders but try not to overlook local firms
Duke Power	• All things being equal, choose the supplier closest to where purchase will be used
Georgia Power	• Point system for evaluating vendors gives extra points for domestic (U.S.) and in-state suppliers
Hydro Quebec	• Product with Quebec content is allowed to be 10 per cent more expensive • Only Quebec bidders allowed if two or more are available • Maintain list of preferred high Quebec content bidders
Pacific Gas & Electric	• Invite foreign bids only when: — there are fewer than 3 domestic bids, or — technology not available in U.S. • Canada considered domestic bidder
Tennessee Valley Authority	• Subtract 6 per cent from price of a domestic (U.S.) bid • Subtract 12 per cent from bid of small U.S. producer

Source: Telesis interviews with each utility.

procurement can help by funding the development of new technologies, testing prototypes, and making the initial purchases of new products. In other businesses, economies of scale in production or after-sales service may be critical to competitive success. Strategic procurement can assist companies in those businesses by helping them build the necessary scale.

In still other businesses, close relations with a major customer can be a significant means of gaining a competitive leg up because they promote applications engineering developments and other product refinements. Strategic procurement can create a close, continuing preferential relationship with critical local suppliers, enabling them to test new applications and perfect product enhancements.

Hydro's Procurement Successes To Date

The one area where Ontario Hydro has successfully applied a more strategic approach to procurement is its nuclear electricity generation program. From the outset of the CANDU program, it was agreed that every effort would be made to develop Canadian suppliers of important components. Another program priority was to develop suppliers that would be capable of participating fully in any CANDU export contracts. The CANDU supplier program had many successes; unfortunately these have been obscured somewhat by the failure to sell more than a handful of CANDU reactors abroad. In those cases where the products bought by Hydro were applicable to other types of reactors, the success of the program is more evident. CAE Electronics, for example, developed a nuclear plant simulator that is now being sold in the United States.

Outside the nuclear program, however, Hydro has mainly followed a local content approach to procurement. These efforts have often been successful in securing local manufacturing of important Hydro components, and in a few cases firms that located in Ontario to supply Hydro have gone on to make significant sales in other provinces or abroad. Exhibit XV.10 details seven procurement cases where Ontario Hydro's buying policies and procurement staff have successfully encouraged new or expanded manufacturing activity in Canada. In the cases of Brown Boveri, Radix, Pitman, CAE, and Westinghouse, the efforts brought new employment. In the cases of Nutah and the CGE/Westinghouse joint venture in extra high voltage transformers, Hydro's efforts were directed mainly at retaining specialized skills and cost competitiveness that might otherwise have been lost.

These procurement successes have sometimes led to sales out-

EXHIBIT XV.10

EXAMPLES OF ONTARIO HYDRO'S USE OF PROCUREMENT TO SECURE CANADIAN MANUFACTURING

Company	Product	Results of Hydro Procurement Policy	Benefits to Canada
Brown Boveri	Turbine Generators for Darlington Station	• Brown Boveri bought 49% of Howden, an Ontario company, to increase Canadian content	• $500 million contract employed 300–400 people; company also providing 3 units for a station in Newfoundland
Radix	Computerized meter reading	• No Canadian manufacturer • U.S. firm established manufacturing in Canada to qualify for contract	• 12 people employed for 2 years in Ontario
Transelectrix Technology Inc. (TTI)	Extra high voltage transformers	• TTI joint venture of CGE and Westinghouse encouraged by Hydro to achieve better scale—$38 million contract won in competitive bid	• Real danger both companies would close because of insufficient scale. • Rationalization keeps at least one Ontario supplier and, with ASEA in Quebec and Federal Pioneer in Manitoba, retains Canadian manufacturing base
Westinghouse	Cable penetration assemblies for Darlington Station	• Westinghouse agreed to transfer $8 million of unrelated work to its Canadian plants	• In addition to the $8 million offset, one of the products transferred has continued to be made in Canada
Pitman Manufacturing	Live line track mounted aerial work platform	More reliable aerial device using fibre optics instead of pneumatics	Company has obtained significant export orders in the U.S., resulting in higher profits & more employment in Ontario
Nutech	CANDU pressure tubes	Takeover of Chase Nuclear's Canadian facilities resulting in substantial price reduction and security of supply	Canadian ownership and expanded manufacturing capability of strategic components in Ontario
CAE Electronics	Generating Plant Simulators	Strategic decision to sole source all simulators with Canadian-owned CAE-Electronics of Montreal	Development of world leading simulators in partnership with Hydro, resulting in major sales in the U.S.

Source: Telesis interviews at Ontario Hydro side Ontario, as with the sale of Brown Boveri-Howden generators to Newfoundland or CAE simulators to the U.S. But on the whole, they are examples of local content purchasing. When dealing with multinationals like Westinghouse, GE, or Brown Boveri, which have well-developed technologies and high world market shares, it may not be realistic to aim at developing export-oriented Ontario suppliers; the local content approach may in fact be the best approach. Products that may inevitably require a local content procurement approach include generators, turbines, and high voltage transformers. But in those areas where the appropriate Canadian skills exist, where technology is changing rapidly, where no firm has product or market dominance, and where Hydro is a major purchaser, Ontario Hydro should be able to take a more strategic approach to purchasing, with the goal of developing competitive export-oriented Ontario suppliers.

Further research would identify areas where Hydro could take a strategic procurement approach, but several candidates were suggested in interviews at Hydro, including computer software for monitoring the electrical grid, micro- wave communication equipment, and sequence of events recorders for fault protection. Another area where strategic procurement could be valuable is the development of world-competitive engineering firms. Unfortunately, for a variety of reasons Ontario Hydro has not capitalized on that opportunity.

The Traditional Hydro Preference for In-House Engineering

Until the last ten years Ontario Hydro followed a deliberate program of developing a large internal staff to handle major project engineering and construction management, instead of contracting such work to private firms. Between 1960 and 1975, Hydro designed and built almost all its hydraulic and fossil fuel plants using internal resources (See Exhibit XV.11). There were only a few exceptions, such as the Lower Notch hydraulic plant built by Acres Consulting in 1971. Since 1975, Hydro has increasingly used outside firms, with Acres designing and managing construction of the small Arnprior hydraulic facility in 1977, Lumnus designing and building the heavy water production facilities at Bruce, and private engineering coalitions handling the Thunder Bay 2 & 3 coal units in 1980-81 and the Atikokan lignite plant in 1985. Hydro plans to continue using outside firms for new small-scale hydraulic plants and some fossil plant rebuilds, although it is constrained somewhat by a 1985 agreement with its engineering union to limit contracting out to 25 percent of all design and construction work.

In nuclear generation, Ontario Hydro has steadily increased its role in plant design and construction management. AECL did 57 percent of all the engineering work on Pickering A, 37 percent on Bruce A, 25 percent on Pickering B, and 16 to 17 percent on Bruce B; it is now doing only 7 to 9 percent of the engineering work on Darlington (which represents the nuclear core only). Hydro felt that it was necessary to become increasingly involved in nuclear plant design and construction for several reasons. Chief among them were AECL's growing efforts to build nuclear plants abroad, a factor that depleted the talent available to manage projects in Canada. In addition, Hydro believed that by managing the work itself, it could assure adherence to its high standards of operating performance and on-time construction; in the future it would also be able to manage and repair more effectively the facilities it had built. This was also why no private engineering firms were invited to bid on design and management of the projects.

Hydro staff point to the dramatic cost overruns and performance problems experienced by many U.S. utilities that used outside contractors to design and build nuclear plants as evidence of the correctness of Hydro's decision to 'make' nuclear plants rather than 'buy' them. Whether Hydro was correct in assuming that it had to manage the design and construction of its nuclear plants is a question that deserves further study. In any case, assuming design and construction control effectively meant that no private engineering firm could emerge with the capability to design and build nuclear plants.

Ontario Hydro's bias toward in-house engineering has been changing since the 1970's. All told Hydro has contracted out at least one billion dollars in engineering and project management work over the past fifteen years. However, this sum consisted of many disparate projects given to a variety of firms. The only truly world-scale projects available in Ontario in recent years would have been nuclear plants, and Hydro kept management of those facilites for itself. Quebec followed a different approach as it developed its world-scale hydro electric potential, centralizing large project management in the hands of a few outside contractors, and thereby greatly boosting their international reputations, skills, and competitiveness. In the next section we describe this different approach in Quebec.

The Different Approach In Quebec

Hydro Quebec has pursued both local content and strategic procurement aggressively and with much success. The foundations for Hydro Quebec's successful use of procurement were laid in the early 1960s. Until that time Acres Consulting, based in Toronto, designed almost all the important electrical power pro-

EXHIBIT XV. 11-A

DESIGN AND CONSTRUCTION OF HYDRO HYDRAULIC GENERATING STATIONS SINCE 1960

Hydraulic Units (In-Service Dates)	Station	Number Of Units	Output MWe	Design by	Construction Managed by
1961–63	Otter Rapids	4	178	Ontario Hydro	Ontario Hydro
1961	Red Rock Falls	2	40	Ontario Hydro	Ontario Hydro
1963	Little Long	2	127	Ontario Hydro	Ontario Hydro
1965	Harmon	2	132	Ontario Hydro	Ontario Hydro
1966	Kipling	2	142	Ontario Hydro	Ontario Hydro
1967	Mountain Chute	2	165	Ontario Hydro	Ontario Hydro
1968	Barret Chute Ext.	2	130	Ontario Hydro	Ontario Hydro
1969	Stewartville Ext.	2	102	Ontario Hydro	Ontario Hydro
1969	Aubrey Falls	2	158	Ontario Hydro	Ontario Hydro
1970	Wells	2	229	Ontario Hydro	Ontario Hydro
1971	Lower Notch	2	260	Acres Consult.	Acres Consult.
1977	Amprior	2	78	Acres Consult.	Acres Consult.

Source: Telesis interviews at Ontario Hydro.

EXHIBIT XV. 11-B

DESIGN AND CONSTRUCTION OF HYDRO GENERATING STATIONS SINCE 1960

Thermal Units (In-Service Dates)	Station	Number Of Units	Output MWe	Design By	Construction Managed By
1961	Hearn 5 To 8	4	800	Stone & Webster	Stone & Webster
1962–63	Lakeview 1 & 2	2	600	OH/St. & Webster.	Ontario Hydro
1965–69	Lakeview 3 To 6	4	1200	OH/St. & Webster.	Ontario Hydro
1969	Lakeview 7 & 8	2	600	Ontario Hydro	Ontario Hydro
1969–70	Lambton	4	2000	Ontario Hydro	Ontario Hydro
1971	Hearn To Gas	4	400	Ontario Hydro	Ontario Hydro
1972	Hearn To Gas	4	800	Ontario Hydro	Ontario Hydro
1973–74	Nanticoke 1 To 4	4	2000	Ontario Hydro	Ontario Hydro
1975–77	Nanticoke 5 To 8	4	2000	Ontario Hydro	Ontario Hydro
1976–77	Lennox	4	2000	Ontario Hydro	Ontario Hydro
1980	Keith Rehabilitation	4	256	Ontario Hydro	Ontario Hydro
1980–81	Thunder Bay 2 & 3	2	300	London-Monenco	London-Monenco
1985	Atikokan	1	200	London-Monenco-Acres-Shawinagan	London-Monenco-Acres-Shawinagan

Source: Telesis interviews at Ontario Hydro.

jects in Quebec. This all changed in the early 1960s, when a conscious decision was made to favour Quebec-based engineering firms. SNC was the first to bid successfully on a major Hydro Quebec project, designing the Manicougan 5 hydraulic facility. The experience and credibility gained by SNC in carrying out the project led to a series of major contracts for hydroelectric projects in various countries.

A second important procurement decision by Quebec was to consolidate the province's seven private utilities and 25 municipal and co-operative systems to form Hydro Quebec in 1963. The rationale for the consolidation was in part to gain economies of scale in operations and uniformity in rates across the province. However, an equally important reason was to consolidate all electrical utility purchasing in the province under a single agency. This concentrated buying power was expected to result in lower prices for equipment and, through preferential procurement, the development of local manufacturing. In 1965-66 Quebec introduced a ten percent price differential policy for Quebec content in Hydro Quebec purchases.

Today, Hydro Quebec's procurement policy is to restrict bidding to Quebec firms if three or more qualified bidders can be found or failing that, to restrict bidding to Canadian bidders if three or more qualified Canadian firms can be found. A ten percent price preference is given for Quebec content. However, on specific items direct negotiations with bidding firms for greater Quebec content can result in effective price premiums that are much higher.

At times Hydro Quebec has solicited foreign firms to set up production facilities in Quebec, offering to set aside a portion of all purchase requirements for that product as an incentive. With transformers, for example, Hydro Quebec was unsuccessful in trying to get GE, Westinghouse, or Ferranti, all of which had underutilized Canadian plants outside Quebec to build plants in Quebec. Eventually, they persuaded ASEA of Sweden, which was not in the Canadian market, to build a plant in Quebec by guaranteeing them a significant percentage of Quebec's future orders.

Quebec can be admired for its aggressive use of procurement preferences, but its successes have often come at the expense of Ontario. In at least seven specific instances, Ontario-based electrical utility equipment manufacturers have been led to move production to Quebec (See Exhibit XV.12). Because Ontario Hydro gives equal preference to all Canadian manufacturers, regardless of location, these firms can still supply Ontario Hydro from their new locations in Quebec as advantageously as they did from Ontario.

EXHIBIT XV.12

MANUFACTURERS IN ELECTRICAL UTILITY SUPPLY BUSINESSES LEAVING ONTARIO FOR QUEBEC

Company	Ontario Location	Year Closed	Product	Action to Service Ontario Market
McGraw Edison	Port Elgin	1982	Distribution Transformers	Moved to new plant in Quebec
Siemens	Downsview	approx. 1982	Motor Controls	Consolidated with existing plant in Quebec
Joslyn	Newmarket	approx. 1984	Line Hardware	Consolidated with existing plant in Quebec
Kearney	Guelph	1985	Switches (Low Rated)	Consolidated with existing plant in Quebec
CGE	Peterborough (parts of plant)	1986	Bus Manufacture and Hydraulic Generator Coils	Moving to new facility in Quebec
CE	Cornwall	1986	Nuclear Fabrication Work	Transfer to Quebec plant
Dominion Cutout	Scarborough	1987	Switches (Low-Rated)	Consolidated with plant in Quebec

Source: Telesis and Canada Consulting interviews at Ontario Hydro and Hydro Quebec.

Quebec's greatest strategic success in using procurement as a tool of economic development has been in the area of consulting engineering. From the point in the early 1960s when the decision was made to give preference to Quebec engineering firms on capital projects, Hydro Quebec has followed a strategic approach to engineering procurement. Unlike Ontario Hydro, Hydro Quebec has emphasized contracting out of engineering and construction management, rather than building large in-house design and construction staffs. At least three factors led Hydro Quebec to adopt this approach:

- A desire to staff internally for the 'valleys', not the 'peaks', of design and construction work
- An interest in bringing in outside thinking to complement Hydro Quebec's internal capabilities
- A belief that experience with Hydro Quebec projects could help to develop Quebec engineering firms as major exporters of their services.

Both SNC and Lavalin have benefited significantly from Hydro Quebec's approach to purchasing consulting engineering services. Lavalin's case was the most dramatic, as it won the 1972 competition to design and build the James Bay hydroelectric complex in co-operation with the much larger Bechtel engineering group (based in the United States) and Hydro Quebec itself. Engineering and project management costs were about $1.5 billion, or ten percent of total project costs. Lavalin managed the overall team and contributed 65 percent of the staff; 25 percent came from Hydro Quebec and ten percent from Bechtel. Having Bechtel involved gave the project credibility in the New York financial community, which raised most of the project financing. It also turned out to be strategically important for Lavalin, which learned a lot from Bechtel's wider international experience, especially in the area of cost control.

Lavalin went on from James Bay to develop a strong international reputation in several engineering fields. The large project management skills gained on the James Bay job were even more important than the experience with hydro development. The fact that Lavalin could bring such a large and complex project in ahead of time and under budget was of tremendous importance to the company's reputation.

The success of Hydro Quebec's strategic purchasing policy for the James Bay project is evident from Lavalin's record since then. Lavalin grew from $30-40 million in sales in 1972 (before James Bay) to $600 million in sales in 1986. In the 1960s and '70s Lavalin's business was 80 percent government and 20 percent private. Now it is 20 percent government and 80 percent private, and Lavalin's engineering sales to foreign markets have grown from five percent of total sales in 1970 to 50 percent today.

Looking back to the 1950s, it is easy to see how powerful the Hydro Quebec procurement lever has been for Quebec's engineering industry. Acres, based in Toronto, was the Canadian leader in large project engineering in the 1960s. They had about 800 professionals in the late 1950s, a time when SNC had only about 100 engineers and Lavalin probably only 50 or so. Today Acres has a total staff of 950, compared to SNC with 3,000 and Lavalin with 7,200. Much of Lavalin's growth has come from mergers and acquisitions, but those were made possible in part by the huge cash flow generated by the James Bay project. Today there is widespread recognition that Montreal is the consulting engineering centre of the country. There were many factors which account for Montreal's success in this regard, and they extend far beyond the role of Hydro Quebec procurement. Similarly, there are a number of reasons why no world-scale engineering firm emerged in Ontario. Nevertheless, the difference in provincial procurement policies played an important role in the development of the engineering industries in the two provinces.

Towards A More Strategic Procurement Policy

Ontario Hydro has had notable successes in using its procurement leverage to encourage Canadian manufacturing. However, much more could be done, especially if a more strategic approach were adopted. This would require a careful review of major anticipated Hydro purchases in the next ten years to identify those where the size of the purchase and the nature of the product might enable a Canadian manufacturer to develop export opportunities based on successful completion of the Hydro contract. The criteria defining such opportunities might include the following:

- A product area where Ontario Hydro is prepared to be innovative
- Products where the technology required for success is still developing and no clear technological direction has yet emerged
- Business areas where there are no clearly established world leaders or firms already dominating most markets
- Products whose markets are too small to interest major multinationals but still large enough to support a small or medium-size Canadian exporter

- Areas where there is already some Canadian expertise and capability.

In general the most likely areas of opportunity will be those where Hydro is prepared to make a development commitment over several years to come up with a new and better product or service. One area that should be examined closely is the major developments surrounding flue gas desulphurization (i.e., coal scrubbing), where Hydro will probably be spending billions of dollars in the 1990s. The state of the art in coal scrubbing still leaves much to be desired from the perspectives of effectiveness and cost; it is entirely possible that Hydro could assist several Ontario firms to develop technology and products in this area. These would most likely have to be products or services related to one of the half-dozen or so basic scrubbing processes being developed and refined in the United States and Japan. Hydro is already funding research into which process is most suitable for their circumstances.

Computer software and services are another area where Hydro could assist in developing unique Canadian capabilities. The recent Hydro order for a major computer-based supervisory and control system from Unisys is an example of a project that might have been the basis for development of an Ontario product if a different procurement approach had been taken several years ago. The system that Unisys will develop for Hydro (with 95 percent of the work being done in the United States) will be world-leading technology, which Unisys will later try to sell in other markets. Unisys was the logical choice for the project, given that they supplied Hydro's existing computer system for this function. Indeed, no indigenous Canadian supplier would have been capable of bidding on the final specified product.

If it had wanted to approach this project differently and develop a Canadian supplier, Hydro would have had to identify the strategic potential of the project five years ago. At that time Canadian firms could have been given research and development contracts enabling them to assist in the design of a new system. Such contracts, common in the U.S. government procurement process, could have helped a Canadian supplier achieve a level of ability adequate to take on the project. Early identification of opportunities and the use of enabling research and development contracts are critical components of any strategic approach to purchasing.

In Volume I of its report, the Premier's Council recommended a more strategic approach to procurement throughout the Ontario government. Key elements of such an approach at Ontario Hydro would include the following:

- Early identification of strategic procurement opportunities
- Close monitoring of the capabilities of Canadian firms in areas of strategic relevance
- Thorough competitive analysis of the strategic potential of such opportunities (e.g., Is there real hope that a Canadian firm can succeed with this product in world markets?)
- Funding of enabling research and development contracts to assist potential Canadian suppliers to develop their expertise and get up to internationally competitive levels of competence
- Clear goals and objectives for Hydro's strategic procurement activities, say, two to three new projects inaugurated every year.

With an integrated and strategically focused procurement program, based on elements like these, Ontario Hydro should be able to go beyond its current approach to procurement, which is oriented mostly towards local content in purchases of goods and services.

THE POTENTIAL FOR SPIN-OFF BUSINESSES

Ontario Hydro has long recognized that its core business, generating and distributing electricity, had the potential to generate spin-off business activities. These have fallen roughly into two categories:

- Activities such as consulting and training, which were a direct result of Hydro's expertise in utility operations and management
- Materials and other by-products of Hydro's electricity generating activities, especially the nuclear operations.

For decades, Hydro has provided advice and training to other utilities, and since the beginning of its nuclear operations, it has sold related materials like Cobalt-60 for a variety of purposes. (Cobalt-60 is actually produced by inserting cobalt into reactors to irradiate it, but it can be considered a by-product of sorts.)

The Role of New Business Ventures

In 1983, Ontario Hydro recognized that to give proper focus and attention to its non-utility business activities, it needed to create a separate division; New Business Ventures (NBV), which began operations in 1984, was the result. NBV has three objectives:

- Profit—to provide earnings that can be used to lower the electricity rates paid by Ontario consumers

- Human Resource Development and Utilization—to provide development opportunities for Ontario Hydro employees, particularly in critical skill areas
- Benefits to Ontario/Canada—to generate additional revenue and employment opportunities for other Ontario and Canadian companies.

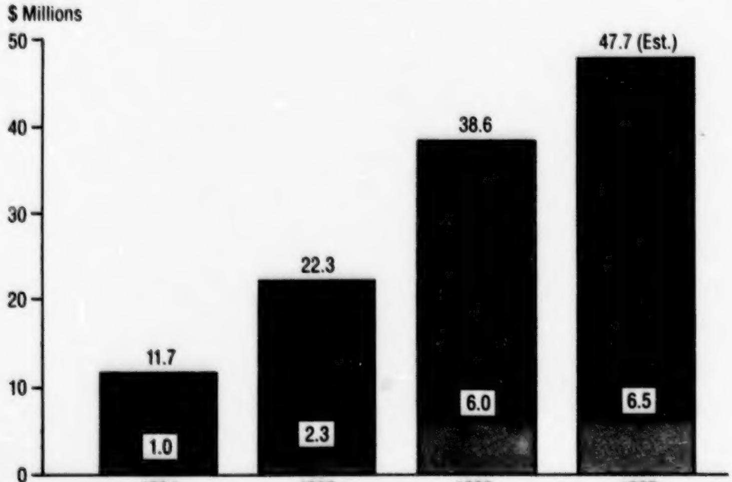
NBV has grown steadily, from $12 million in sales in 1984 to an estimated $48 million in 1987 (See Exhibit XV.13). Sales are divided among four businesses: Isotope Sales, Consulting and Training Services, Technology Products and Services, and Heat Energy Services (See Exhibit XV.14).

Isotope Sales

Roughly 65 percent of NBV's sales in 1987 were in isotopes and related products and services. The majority of isotope sales

EXHIBIT XV.13

REVENUE AND PROFIT GROWTH OF NEW BUSINESS VENTURES DIVISION
1984–1987



Source: Ontario Hydro New Business Ventures Division.

EXHIBIT XV.14

NEW BUSINESS VENTURES—THE FOUR BUSINESS SEGMENTS

	Approximate Share Of Revenues	Products	Major Markets
Isotope Sales and Service	65%	Cobalt-60, Heavy Water, Deuterium Gas, and Tritium	CANDU Utilities, Chemical Companies in Developed Countries and AECL
Consulting and Training Services	22%	Utility Mgmt., Utility Training, Other Utility Expertise	Africa, Mideast, Asia, Turkey
Technology Products and Services	13%	Simulation, Power System Control, Nuclear Services & Technology, Fossil/Hydraulic Services, Power Equipment Testing	Canada, USA, CANDU Utilities, Selected Others Worldwide
Heat Energy Sales and Services From Bruce Station	Minimal	By-Product Heat, Curtailing Steam, and Refuse Disposal	Businesses And Municipalities Near Bruce

Source: Ontario Hydro New Business Ventures Division.

were Cobalt-60, which is used in cancer treatment; in the treatment of toxic waste, sewage, and bacterial and viral waste; medical sterilization applications; and food irradiation for sterilization and preservation purposes. Ontario Hydro has 80 percent of the world market in Cobalt-60, and this product contributes most of NBV's profits (See Exhibit XV.15).

Other isotope products include heavy water, which Hydro sells to nuclear plant operators as well as to non-nuclear markets around the world. Hydro has about 80 percent of the world industrial heavy water market. Deuterium gas, which Hydro manufacturers from heavy water, is a relatively new product used mainly in research laboratories, particularly for fusion research. Hydro has captured 30 percent of this tiny but emerging market. Another by-product of deuterium gas production is Oxygen^{18} which has important potential applications in medical research and could become a significant market on its own.

A major future opportunity may lie in another by-product, tritium, which could have major applications in lighting and fusion energy research. Hydro has invested in new technology to imbed tritium in plastic to make it useful, safe, and controllable. Tritium lights could be extremely helpful in environments where no energy source is available for lighting, such as remote airport runways and helicopter landing systems. They would provide dependable light for up to 20 years. Tritium will also be important in fusion energy development.

In each of these cases, NBV has given a product development and marketing focus to businesses that might otherwise have been viewed as low-priority sidelines. In the cases of deuterium and tritium, NBV has been investing significantly in research and development to create new business opportunities. For example,

EXHIBIT XV.15

ONTARIO HYDRO ISOTOPES AND OTHER BY-PRODUCTS WORLD MARKET SHARES

Cobalt-60	80%
Heavy Water	80%
Deuterium Gas	30%
Ox^{18}	N/A[1]
Tritium	N/A[1]

1. World markets are tiny as yet.

Source: Ontario Hydro New Business Ventures Division.

NBV supported the development of deuteriated lubricants and their production by a biotechnology process. These lubricants would have much reduced rates of deterioration and thus might be suitable for many specialty applications.

Consulting and Training Services

NBV also manages an active consulting and training business, employing more than 100 of Ontario Hydro's staff on outside projects since 1984. Most of these projects involve the sale of specialized expertise in hydro, thermal, nuclear, or transmission operations. Major markets are in Africa, the Mideast, Asia, and Turkey. Much of the project financing comes from the Canadian International Development Agency and international development banks like the World Bank and the Asian Development Bank. Over 30 projects are in joint venture with Canadian consulting and manufacturing companies. NBV has negotiated an agreement with the Consulting Engineers of Ontario not to compete against member companies in the international market.

Training services are provided both overseas and at Hydro's facilities in Ontario. The number of training days supplied increased from 1,046 in 1984 to 8,200 by 1986. As with consulting services, the training draws on many aspects of Hydro expertise in electricity generation and transmission. All told, consulting and training services account for about 22 percent of NBV revenues.

The outside contracts provide a way to market Hydro expertise while encouraging staff development. In a recent internal survey, 97 percent of all Hydro staff that had worked on NBV assignments felt their personal growth had been enhanced by the NBV experiences, and 89 percent believed their job knowledge and skills had increased as a result.

All staff are charged to NBV projects at full cost, including overheads, to ensure that no subsidy is involved. Nevertheless, problems of resource allocation do occur. In particular, the best and most capable Hydro staff are often found to be the most qualified and most interested in working on outside projects. Conflicts can arise over the advisability of releasing such resources from Hydro's core business to external projects. NBV is still valued for the career experience it offers Hydro staff, but it will come under increasing pressure not to expand its consulting services if staffing gets tighter at Hydro.

Technology Products and Services

This business accounts for 13 percent of NBV revenues and is responsible for enhancing and marketing specialized technologies and services developed originally for Ontario Hydro's needs. Typical sales include nuclear plant operation simulation services, performance testing of a variety of devices, nuclear inspection services, and other specialized activities. Technology Products and Services is the major area where NBV projects involve outside companies. In 1986 this business had only $6 million in sales, but more than $3 million worth of spin-off work was awarded to other Canadian firms as a result of successful Hydro contracts.

Through this business NBV also sponsored a "Manufacturing Opportunities Show" with the Ontario Ministry of Industry, Trade and Technology to exhibit products and services that Hydro has developed and would like to transfer to Ontario companies for production and sales. This show has resulted in several successful technology transfers to Ontario manufacturers.

Heat Energy Projects

A fourth business in the NBV Division is the marketing of process steam and hot water, which are by-products of Ontario Hydro's thermal and nuclear plants. NBV takes responsibility for land and facility development next to the generating stations, recruitment of appropriate industries, and identification of new business opportunities where customers can take advantage of the cheap heat. The Ontario government has contributed significant grant funding to infrastructure for these projects.

The largest such project is the Bruce Energy Centre, a 600-acre industrial and agricultural park adjacent to Hydro's Bruce Nuclear Development. Industrial activity at the site has been slow to develop, but the long-term prospects for using the heat energy remain positive. The development of the site will also help ease the employment adjustment necessary as the amount of construction work remaining on the Bruce site declines.

The Heat Energy Projects group has not contributed significant revenue to date, and the business will never earn a return on investment comparable to that expected in the private sector. Nevertheless, it represents an important effort by Ontario Hydro to make economic use of by-product energy and to contribute to regional development efforts.

Summary of NBV Issues

NBV has been remarkably successful in achieving its original mandate of consolidating Hydro's non-utility businesses under a single management and identifying opportunities to expand these businesses to serve its three objectives. NBV is now at a crossroads, however, and Hydro will need to consider carefully what role NBV should play in the future. At least three major constraints are inhibiting NBV's future growth:

- Ontario Hydro's inability to create subsidiaries and to take equity positions in businesses has handicapped the development of Ontario companies which could add value to Hydro's already advantageous position in isotopes. It also inhibits NBV from taking risks that are appropriate to its businesses but inappropriate for Ontario Hydro as a public utility
- NBV's difficulty in minimizing negative public reaction to Ontario Hydro if NBV supported businesses fail or with regard to the marketing of radioactive materials.

Over and above these specific constraints is the general problem of defining NBV's primary role. Is the division to be a marketer of Hydro by-products and expertise, or is it to function as a truly independent business driven by market opportunities? To date most people at Hydro have clearly seen NBV in the former role, while NBV staff see the latter role as the preferred route for future success.

A final issue for NBV is whether it is offering sufficient assistance to Ontario companies to become major exporters of products and services. One could argue that NBV is doing too much internally and should make more use of Ontario contractors. However, this argument misses two fundamental realities of business in NBV's markets.

The first is that competitive success in selling to many less developed countries is often enhanced by being a government-owned corporation. Government ownership gives buyers some security that the company is sound, as well as a degree of comfort in dealing with another government rather than a strictly private organization.

The second competitive reality of many of NBV's businesses is that there are advantages to scale. In the isotopes businesses NBV can capture scale advantages in manufacturing, marketing, and R & D. Even in the consulting and training businesses, there are advantages of scale in marketing large projects in far-flung places and in processing trainees through standardized courses. Ontario has very few indigenous, non-raw material-based, exporting companies of sufficient scale to be competitive in world markets. If NBV's activities were given to smaller firms, some of its advantages of scale in related products and activities would be lost.

The policy objectives of the Premier's Council are to foster internationally competitive businesses in traded goods and services with high value-added per employee. NBV by and large contributes to these goals. Although NBV is investigating the possibility of a private commercial fibre optic network on Hydro transmission poles and is involved in the sale of waste heat, which are not in themselves traded businesses, such enterprises could be of assistance to traded businesses by lowering their cost of raw materials or service inputs.

The Future Role of NBV

If one accepts that NBV is a largely successful mechanism for fostering the growth of high value-added spin-off exports based on Hydro's core operations, the question becomes one of how NBV can expand its activities. NBV has identified many areas of expansion opportunity, including:

- New markets for Cobalt-60
- Tritium for lights and fusion energy
- Deuterium gas and other deuterium-based products
- Oxygen 18
- International consulting and training
- Utility management and power system software sales
- Nuclear services and products in the United States
- Licensing of specific Hydro technologies to private sector firms.

To pursue these opportunities successfully, Ontario Hydro will need, at a minimum, more flexibility from the Power Corporation Act to invest in and create subsidiaries as appropriate. With increased flexibility and a clear mandate for growth, NBV estimates it could double sales to $100 million by 1992. But we wonder whether a much broader restructuring of NBV will not be required if it is to achieve its potential.

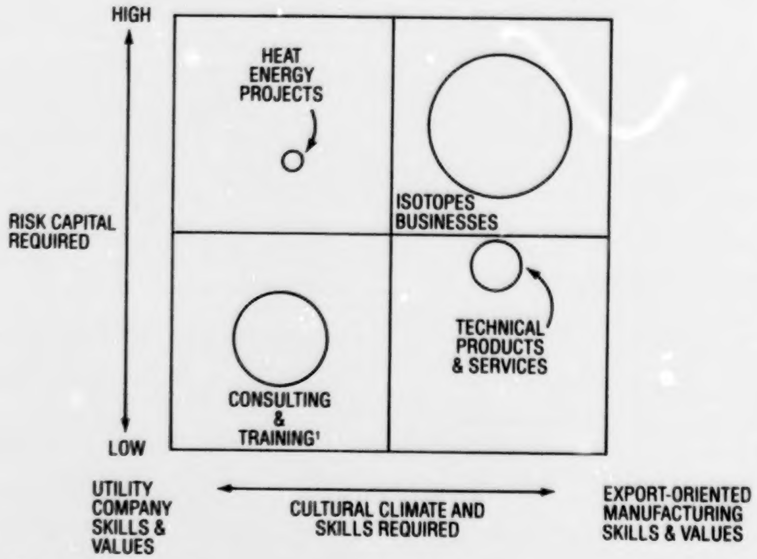
The businesses NBV is anxious to expand have quite different capital requirements and necessitate different organizational cultures. (We have described these differences graphically in Exhibit XV.16.) The consulting and training business requires little risk capital and can operate as an extension of Hydro's basic skills and corporate cultural values. The dedication to performance excellence, safety, and reliability that motivates Hydro as a whole is also close to the appropriate value structure for a utility consulting and training business. Of course, marketing skills and overseas risk taking are required in addition to the usual Hydro skills and values, but the consulting and training activity is fundamentally similar to what Hydro already does. So are the heat energy projects, although they require much more capital investment than do consulting and training businesses.

As we move towards NBV's technology products and services

EXHIBIT XV.16

NATURE OF HYDRO SPIN-OFF BUSINESSES

Risk Capital Intensity Versus Cultural Climate and Skills Required


HIGH
RISK CAPITAL REQUIRED
LOW
HEAT ENERGY PROJECTS
ISOTOPES BUSINESSES
TECHNICAL PRODUCTS & SERVICES
CONSULTING & TRAINING¹
UTILITY COMPANY SKILLS & VALUES
CULTURAL CLIMATE AND SKILLS REQUIRED
EXPORT-ORIENTED MANUFACTURING SKILLS & VALUES

Note: Circle sizes are proportionate to current revenues in each business area.

1. If the consulting services were sold through "Build, Operate and Transfer" agreements with foreign countries, as many utility projects are today, then the risk capital required would be significant and the skills needed would be closer to the manufacturing side of the horizontal axis.

Source: Telesis analysis.

and isotopes businesses, the degree of cultural similarity to Hydro's core activities diminishes. For example, the skills and organizational values required for success in the tritium lighting business will be very different from Hydro's usual strengths. In these other businesses, especially isotopes, the risk capital required also increases significantly. In these businesses NBV may be handicapped by its close ties to and integration with the core Hydro organization. Indeed, NBV will have to be highly market-driven to succeed in these businesses. Risk capital will be needed for R & D, product testing and launch, manufacturing investments, and marketing investments.

It is not clear what organizational form would best suit NBV, but it is possible that a more separate group with the ability to create a distinct corporate culture and to raise risk capital independently might be more successful in the long run. Such an organization would need to maintain close links to Hydro but should also have the independence necessary for success and the opportunity to refashion itself as a diversified manufacturing and service firm dedicated to high value-added export opportunities. Ownership of such an organization might more appropriately be shared with employees and outside investors. Over time, the organization could become one of the province's threshold companies and a major participant in high-growth export markets.

THE OPPORTUNITIES IN HYDRO R & D

Ontario Hydro conducts the largest research and development effort of any North American utility (See Exhibit XV.17). The only two organizations with larger R & D budgets are not utilities; the Electric Power Research Institute (EPRI) in California and IREQ in Quebec are research houses that contract with utilities for R & D projects, although IREQ is closely tied to Hydro Quebec. The focus of most of Hydro's R & D is in solving specific utility problems, but some of it has the potential to lead to new products and services that could be marketed by Ontario companies or by Hydro's New Business Ventures Division. (Many of these products will find only special and limited niches, and marketing strategies must be devised that are appropriate to the product at hand.)

Altogether, Hydro spent $92 million in 1986 on research and development. Of this about $60 million was spent in the Hydro Research Division. A total of 670 people are employed in the Research Division, including 300 professionals, 270 technicians, and 100 support staff. Of the Research Division budget of $60 million, about 40 percent is charged directly to other Hydro divisions, a little over 10 percent is charged to outside clients, and the remainder is purely discretionary—in other words, it is spent on projects of the Research Division's choice. The discretionary portion of the research has fallen significantly since 1975, as Hydro has tried to tie all research more closely to specific clients and objectives (See Exhibit XV.18).

The Research Priorities

The types of research activities undertaken range widely, depending on who the client is. About 60 percent of the work done for other Hydro divisions is short-term technical problem solving and one-time special projects; another 40 percent is longer-term development work on reactor inspection, fuel channel materials, artificial intelligence, non-destructive testing, sulphur dioxide abatement, and other subjects. The outside client work covers a wide area, including vibration monitoring, corrosion fatigue, heat pumps, fish migration, microwave technology, and

EXHIBIT XV.17

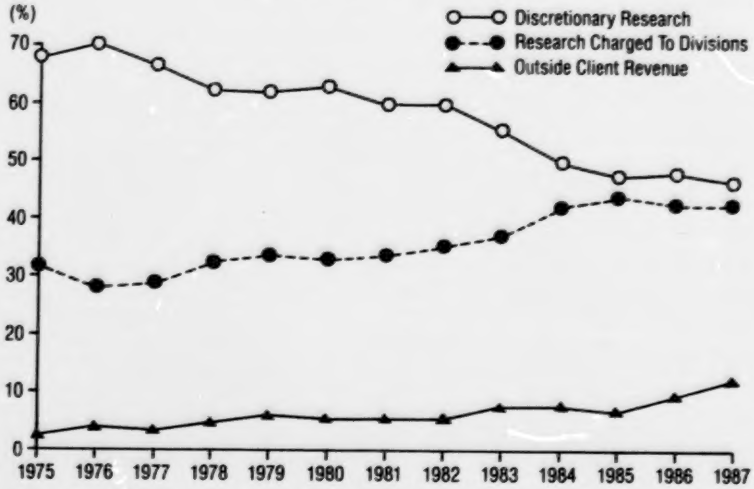
TOP NORTH AMERICAN ELECTRIC UTILITY RESEARCH ORGANIZATIONS
(ranked by R&D budget in CDN $ Millions)

Name	Location	1986 R&D Budget ($MM)	R&D Professionals	1986 Sales Revenues ($MM)	Major Research Areas
Electric Power Research Institute (EPRI)	Palo Alto, CA	438	350	Not A Utility	• Many
IREQ	Quebec City, P.Q.	100	200	Not A Utility	• High voltage transmission
Ontario Hydro	Toronto, Ontario	92	300	4,853	• Many
Tennessee Valley Authority (TVA)	Nashville, TN	75	200	5,799	• Many
Alberta Research Council	Edmonton, Alberta	49	215	Not A Utility	• Contract For Government
Consolidated Edison	New York, N.Y.	39	40	6,497	• System Testing
Pacific Gas & Electric	San Franciso, CA	34	50	6,959	• Solar Energy • Plant Improv.
Niagara Mohawk	Syracuse, N.Y.	34	19*	2,620	• Product Dev. • Testing
American Electric Power Service Corp.	Columbus, OH	33	N/A	4,843	• Clean Coal • Demo. Plant
Detroit Edison	Detroit, MI	31	110	3,500	• Transmission • Load Conserv.
Duke Power	Charlotte, N.C.	30	50*	4,161	• Tactical Research
Empire State Electric Energy Research Corp. (ESEERCO)	New York, N.Y.	25	14*	Not A Utility	• N.A.

* Denotes a company that contracts out much of its R & D.
Source: Telesis interviews with utilities.

EXHIBIT XV.18

ONTARIO HYDRO RESEARCH DIVISION ALLOCATION OF RESEARCH COSTS
(as % of annual total)



Source: Ontario Hydro Research Division.

other areas. Generally, Hydro will not do outside contract research unless it is of some interest to Hydro as well. Priorities for discretionary research are set after wide consultation within Hydro on what research is most needed. All large discretionary projects must be endorsed by other divisions before it can proceed.

Hydro's Research Division activities are spread across most aspects of electrical utility operations (See Exhibit XV.19). The largest amount, 38 percent in 1986, is spent on nuclear generation projects, followed by transmission system activities. The only area where spending has increased significantly as a proportion of total research is conservation and alternative energy projects, which rose from four percent of the total in 1982 to six percent in 1986 and are expected to rise to nine percent in 1990. The breadth of research activity is both Hydro's strength and its weakness. It is a strength because Hydro is able to respond to almost any technical challenge in any aspect of its basic businesses. It is a weakness in that no critical mass of research effort capable of major breakthroughs is assembled in any one area.

EXHIBIT XV.19

ONTARIO HYDRO RESEARCH DIVISION EXPENDITURES BY PROGRAM AREA

(as % of total gross expenditures)

	Actual		Forecast	
	1982	1986	1990	1997
Nuclear Generation	33	38	37	36
Transmission System	11	10	10	10
Environmental	11	7	9	8
General Research	9	10	9	10
Supporting Activities	8	9	7	7
Electric Power Supply	6	6	7	8
Nuclear Waste	6	4	4	4
Thermal Generation	6	3	2	2
Conservation & Alternative Energy	4	6	9	9
Distribution Systems	4	4	4	4
Hydraulic Generation	2	3	2	2
Total	100%	100%	100%	100%

Source: Research Division Business Plan 1988–97.

Until ten years ago, the Research Division saw its objective as basically to support Hydro needs. Gradually, it has evolved to a view that recognizes a secondary objective, that of supporting provincial economic development more broadly, especially the needs of Ontario industry. Hydro research can benefit Ontario industry in several ways:

- Assisting Ontario industry to exploit new, efficient electrotechnologies
- Testing of company products and services
- Development of new products that can be licensed or given to industry for sale to other clients
- Contract research for companies in areas of Hydro expertise
- Joint development projects in areas of mutual interest.

EXHIBIT XV.20

EXAMPLES OF PRODUCT COMMERCIALIZATION RESULTING FROM ONTARIO HYDRO RESEARCH EFFORTS

Product	Description	Commercial Results
Soniscope	• Testing device, developed in 1950s • Uses ultrasonic pulses to locate cracks in concrete • Originally licensed for production to McPhar Engineering (Toronto) and marketed worldwide	• Modernized instrument now developed jointly by OH, CEA, and Hydro-Quebec • Commercialization program currently under development
PCB Extraction Process	• Removes harmful PCBs from transformer oils	• Built by Emervac (Cambridge) in 1985 • Mobile unit marketed and operated by local firm
Programmable Controller	• Electronic controller for Darlington Nuclear station	• Design licensed for manufacture and marketing to Trench Electric in 1985
Maximum Demand Indicator	• Device used in metering of large customer loads, as backup system	• Stratrel Ltd. (Ontario) requested and received licence to produce and market product
Fish Repulsion	• System uses light and sound to repulse fish from intake areas and attract them to fish ladders	• Canadian company licensed to sell and market product to other utilities and hatcheries

Frequency Trend Relay	• Developed in 1967, minimizes effect of power system disturbances	• Contract awarded to Tele-Radio to produce for Hydro's needs; then it was licensed to sell elsewhere • Design updated in late 1970s, revised product still sold
Fly Ash Use In Concrete	• Defined potential uses in concrete of fly ash and bottom ash from coal-fired stations	• Liability to Hydro transformed into an economic benefit to the construction industry
Partial Discharge Analyzer	• Technology developed to determine status of hydrogenerator's winding insulation	• Licensed to FES International (now a Canadian company) who are now selling the product worldwide
Ampere Cycle Totalizer	• Device to calculate the wear in high-voltage circuit breakers	• Licensed to Double Engineering to manufacture and market to utilities worldwide

Source: Telesis and Canada Consulting interviews at Ontario Hydro.

Hydro has had a number of notable, if small, successes in developing products for internal needs that were subsequently marketed by Ontario companies. Some of these are described in Exhibit XV.20.

Getting More Leverage Out of Current Efforts

In its present configuration, Hydro's R & D effort plays an important role in support of the utility's technical needs. It has also resulted in the development of small-scale industrial spin-off products. Most of the R & D now done could be described as process technology and problem solving; almost none of it is product development. To be really effective in generating new product opportunities from its research activities, the Research Division would probably need to focus explicitly on product development. However, such a change would be fraught with difficulties.

To be successful, laboratories need clearly defined missions. Today, most of the Research Division's activities do follow a clearly defined mission: supporting Hydro's basic utility business. To give the Research Division a product development mission without an attendant industrial client base to manufacture and market the products would be a recipe for failure. On the other hand, given the paucity of large R & D facilities in Ontario and Hydro's broad capabilities, it seems logical that Hydro's Research Division should be encouraged to play a greater role in provincial economic development.

Precisely what that role could be is something Hydro should study. The driving discipline for any substantial new Hydro research programs must come from a clearly defined client base. The most logical place to look for such clients would appear to be in the other two areas of Hydro development leverage: procurement and spin-off businesses. The Research Division could play an important role in supporting the enabling research and development work that must be a part of any major Hydro strategic procurement projects. The Research Division could also play an important role in supporting the development needs of a reconstituted New Business Ventures Division with broader business scope and access to risk capital.

Are these the most appropriate ways to get further leverage from the province's investment in one of the world's largest electrical utility research programs? The issue requires further study. At a minimum, Hydro should carry out a complete audit of the commercial potential of its research capabilities and identify those areas where product development efforts could be fruitful. In all cases, clearly identified clients must exist before any spin-off development work proceeds.

CONCLUSION

The potential for greater use of Ontario Hydro as an agent of economic development beyond its central mandate is quite significant. Hydro procurement has been a successful development lever, but procurement needs to become more strategic, identifying opportunities early and using R & D contracts to bring potential Ontario suppliers up to world levels of technology. Hydro has had substantial success in capitalizing on some of the spin-off potential of its base businesses. The New Business Ventures Division can go much further and could become one of Ontario's important threshold companies if it is given more organizational freedom and access to the risk capital necessary to become a major manufacturer and international marketer of high technology products and services. Hydro's R & D efforts have led to business opportunities for some provincial companies. With appropriate client support, Ontario Hydro should be able to gain even more leverage for the province from its already substantial investment in R & D. Ultimately, Hydro's activities in each of these areas—procurement, spin-off businesses, and R & D—should reinforce one another. An integrated development strategy should be developed, building on what has already been achieved and focussing future efforts on a small number of high potential opportunities where Hydro can make a substantial contribution to the development of indigenous Ontario export businesses.

APPENDIX A
PREMIER'S COUNCIL STUDY TEAM

Canada Consulting Group

Study Director:	Neil Paget
Associates:	David Caldwell Anne Donaldson-Page Lucille Fowle

Telesis

Study Director:	David Pecaut
Advisor:	Ira Magaziner
Associates:	Ian Bromley Thor Johnson Tom O'Brien Joanne Riccitelli Ed Wood

Premier's Council Secretariat

Deputy Secretary:	Helen Burstyn
Senior Policy Advisors:	Rob McLeod Gerry Pisarzowski
Research Assistant:	Janice Wright